Air Quality Monitoring

Onsite Industrial Monitoring in The Lakeland Area

Spring and Fall of 2003 and 2004 — Final Report

Introduction

Alberta Environment conducts mobile air quality surveys each year as part of its air quality monitoring program. These monitoring surveys are unannounced and use the Department's *Mobile Air Monitoring Laboratory* (MAML). The MAML provides a 'snapshot' in time and space of the air quality at the location monitored. Pollutants measured by the MAML included ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, hydrogen sulphide, total reduced sulphur and sulphur dioxide.

Alberta Environment conducted an ambient air quality monitoring survey in the Lakeland area of Alberta in the Spring and Fall Seasons of 2003 and 2004. This study was unique from other ambient air quality monitoring surveys performed by the Department. There were eight monitoring locations chosen for this on-site (within the fence line of industrial facilities) study. Typically, ambient air quality monitoring is done off-site. Each monitoring location was selected in consultation with local industry and other stakeholders. ***Alberta Ambient Air Quality Objectives do not apply to on-site industrial air quality. In Alberta, occupational safety and health exposure guidelines apply to worksite air quality.*** Industrial site operators in the Lakeland Area may find this report useful for comparing Alberta Environment's onsite measurements of pollutants to occupational safety and health exposure guidelines.

Alberta Environment used the same methodology in this survey as employed in all other mobile air monitoring projects; each monitoring location was monitored for a minimum of one hour. The survey obtained 33 hours of air quality data. This report presents the results of the Spring (May 26 to 29, 2003 and June 3, 2004) and Fall (September 8 to 11, 2003 and September 15 and 16, 2004) surveys. Results from other mobile surveys and 2003 data from permanent monitoring stations in Alberta are also presented in the Appendices of this report for comparison purposes.

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Overview

(1) A summary of concentrations of air pollutants measured in the 2003 – 2004 Onsite Industrial Lakeland Area survey can be found in Table 1.

Table 1: Summary of MAML Monitoring results in the Lakeland Area.

Pollutant	Units	Minimum	Median	Maximum
Ammonia **(NH_3)**	ppm	bd	bd	0.196
Carbon Monoxide **(CO)**	ppm	bd	0.1	0.8
Hydrocarbons – Methane **(CH_4)**	ppm	1.8	2.5	8.4
Hydrocarbons – Reactive Hydrocarbons **(RHC)**	ppm	bd	0.2	13.6
Hydrocarbons – Total Hydrocarbons **(THC)**	ppm	1.9	2.8	15.8
Hydrocarbons – Polycyclic Aromatic Hydrocarbons **(PAH)**	ng/m^3	0.2	0.8	21.1
Nitrogen dioxide **(NO_2)**	ppm	bd	0.002	0.031
Nitric Oxide **(NO)**	ppm	bd	0.003	0.076
Oxides of nitrogen **(NO_x)**	ppm	bd	0.004	0.097
Ozone **(O_3)**	ppm	0.018	0.037	0.049
Particulates – Total Suspended Particulates **(TSP)**	$\mu g/m^3$	4	19	195
Particulates – Particulate Matter <10µm **(PM_{10})**	$\mu g/m^3$	3	12	102
Particulates – Particulate Matter <2.5µm **($PM_{2.5}$)**	$\mu g/m^3$	1	2	18
Sulphur Compounds - Hydrogen Sulphide **(H_2S)**	ppm	bd	bd	0.020
Sulphur Compounds - Total Reduced Sulphur **(TRS)**	ppm	bd	0.001	0.020
Sulphur Dioxide **(SO_2)**	ppm	bd	0.002	0.030

$\mu g/m^3$ – micrograms per cubic metre of air ppm – parts per million ng/m^3 – nanograms per cubic meter of air

AAAQO – 1-hour Alberta Ambient Air Quality Objective n/a – no one-hour objective bd – below detection limit

(2) High concentrations of hydrocarbons were measured at some of the on-site monitoring locations. The highest one-hour methane concentration of 8.4 ppm was measured on September 11, 2003 at Exxon Wolf Lake. The highest one-hour concentrations of both reactive hydrocarbons (13.6 ppm) and total hydrocarbons (15.8 ppm) were measured at EnCana Foster Creek on September 10, 2003. Elevated concentrations of methane and reactive hydrocarbons at these locations may be attributed to minor leaks from tanks, flanges, pipefittings and compressors. The highest polycyclic aromatic hydrocarbon concentration of 21.1 ng/m^3 was measured the EnCana site on September 16, 2004. This elevated concentration is likely due to emissions from truck loading operations.

(3) Hydrogen sulphide (H_2S) and total reduced sulphur compounds (TRS) concentrations measured at on-site locations were generally very low, however, a number of higher readings were measured. The highest one-hour H_2S and TRS concentrations of 0.020 ppm were measured at Imperial Oil's Mahkeses Plant on September 11, 2003. This concentration may be attributed to venting from a pressure relief valve. Previous measurements on the plant site were 0.001 ppm and 0.002 ppm. EnCana Foster Creek also had notably elevated concentrations and high readings at this site may be attributed to fugitive tank emissions or maintenance of storage vessels.

(4) The highest one-hour ammonia concentration of 0.196 ppm was measured at the private cattle feedlot on May 26, 2003; this elevated concentration is probably due to decomposing animal wastes. Ammonia concentrations at the remaining on-site monitoring locations were generally very low.

(5) Carbon monoxide, oxides of nitrogen, particulate matter and sulphur dioxide concentrations measured at on-site locations during the surveys were low.

(6) On May 28, and September 10, 2003, strong hydrocarbon odours were noted at EnCana's Foster Creek site by Alberta Environment's staff; the MAML's instruments also measured high reactive hydrocarbon concentrations. Therefore, canister sampling equipment was deployed and later laboratory analysis was conducted to determine the possible species (or types) of volatile organic compounds (VOC) near Encana's Foster Creek operations. Samples were collected using six litre stainless steel electro-polished (SilcoSteel) canisters and were analyzed for more than 150 VOCs. Environment Canada's Environmental Technology Centre in Ottawa conducted the preparation and analysis of the VOC samples. Several compounds were found to be present in ambient air at the EnCana site however *most* were found to be below their respective odour thresholds. Site operators may find the VOC analysis useful in assessing worker exposure to different organic compounds.

The Mobile Air Monitoring Laboratory (MAML)

The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

- **a dual computer system custom-programmed to accept and record the measurement of air samples from each analyser,**
- **a GPS (Global Positioning System) that identifies the MAML's location as it moves around Alberta,**
- **an exhaust purifying system that minimizes emissions from the vehicle and**
- **two on-board generators that are also equipped with exhaust scrubbers**

The pollutants measured by the MAML are listed in Table 3.

Figure 1: **Alberta Environment's Mobile Air Monitoring Laboratory**

Table 2 **Pollutants monitored by the MAML (including minimum detection limits and operating ranges).**

Pollutant	Operating Range	
	Lower Detection Limit*	**Upper Detection Limit****
Ammonia **(NH_3)**	0.001 ppm	5 ppm
Carbon Monoxide **(CO)**	0.1 ppm	50 ppm
Hydrocarbons – Methane **(CH_4)**	0.005 ppm	10 ppm
Hydrocarbons – Reactive Hydrocarbons **(RHC)**	0.005 ppm	20 ppm
Hydrocarbons – Total Hydrocarbons **(THC)**	0.005 ppm	20 ppm
Hydrocarbons – Polycyclic Aromatic Hydrocarbons **(PAH)**	3 ng/m^3	1000 ng/m^3
Nitrogen dioxide **(NO_2)**	0.001 ppm	1 ppm
Nitric Oxide **(NO)**	0.001 ppm	1 ppm
Oxides of nitrogen **(NO_x)**	0.001 ppm	1 ppm
Ozone **(O_3)**	0.001 ppm	0.5 ppm
Particulates – Total Suspended Particulates **(TSP)**	1 $\mu g/m^3$	1.0 g/m^3
Particulates – Particulate Matter <10µm **(PM_{10})**	1 $\mu g/m^3$	1.0 g/m^3
Particulates – Particulate Matter <2.5µm **($PM_{2.5}$)**	1 $\mu g/m^3$	1.0 g/m^3
Sulphur Compounds - Hydrogen Sulphide **(H_2S)**	0.0006 ppm	1 ppm
Sulphur Compounds - Total Reduced Sulphur **(TRS)**	0.0006 ppm	1 ppm
Sulphur Dioxide **(SO_2)**	0.0006 ppm	1 ppm

ppm - parts per million

ng/m^3 = nanograms per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

g/m^3 = grams per cubic metre

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.

Monitoring Method and Locations

Alberta Environment used the MAML to monitor air quality in the Lakeland are. Monitoring was conducted near industries and in the communities. Air quality was monitored on the following dates, representing the spring and fall seasons:

- **Spring (May 26 to 30, 2003 and June 3, 2004)**
- **Fall (September 8 to 11, 2003 and September 15 and 16, 2004)**

The monitoring sites were selected based on public concern, consultation with the Lakeland Industry and Community Association (LICA) and select industrial facilities chosen by regional staff from Alberta Environment with consultation with local industries. MAML monitoring sites are presented in Figure 1 and described in Table 4.

Monitoring was conducted for a minimum of one hour at each location; a total of 33 hours of data was collected at 8 sites.

Table 3 Locations monitored by the MAML (2003-2004 Lakeland Area survey).

Monitoring Location	Dates Monitored			
	Spring	Fall	Spring	Fall
	May 03	Sep 03	June 04	Sept 04
13. Private Feedlot	26	8, 11		
14. Grande Centre Landfill	29	9, 10		
15. CFB Cold Lake	27, 29	9, 11		
16. Exxon Mobil Wolf Lake. LSD 15-12-63-6W4M	28, 29	11		
17. Encana Foster Creek. LSD 22-70-4W4M	28	10	3	16
18. CNRL Primrose. LSD N1/2-5-67-4W4M			3	16
19. Imperial Oil Mahkeses	27, 29	9, 11		
20. JACOS Hangingstone. LSD 13-26-84-11W4M				15

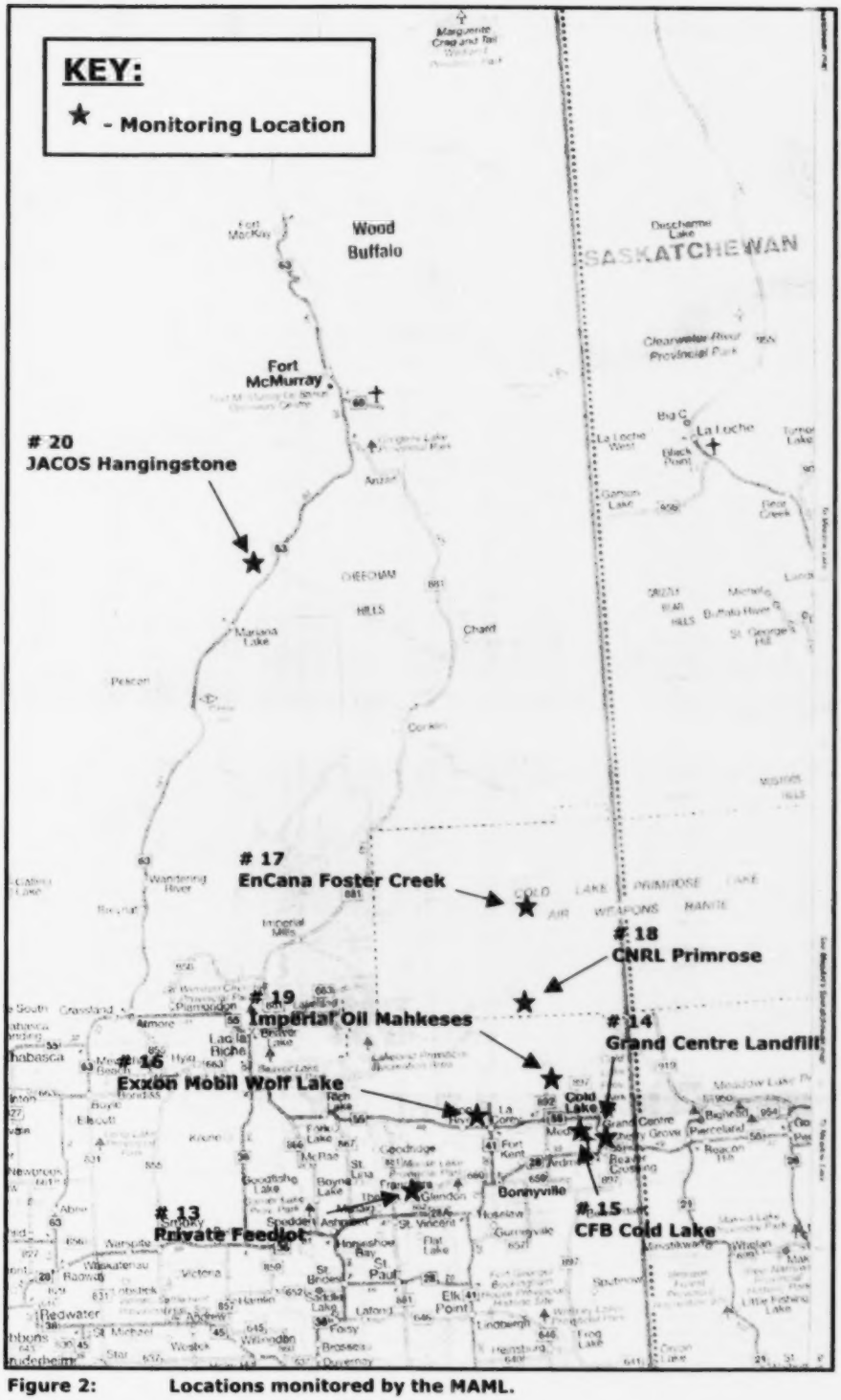

Figure 2: Locations monitored by the MAML.

Adapted from: MapArt, Alberta Road Atlas © 2004

Monitoring Site Photographs

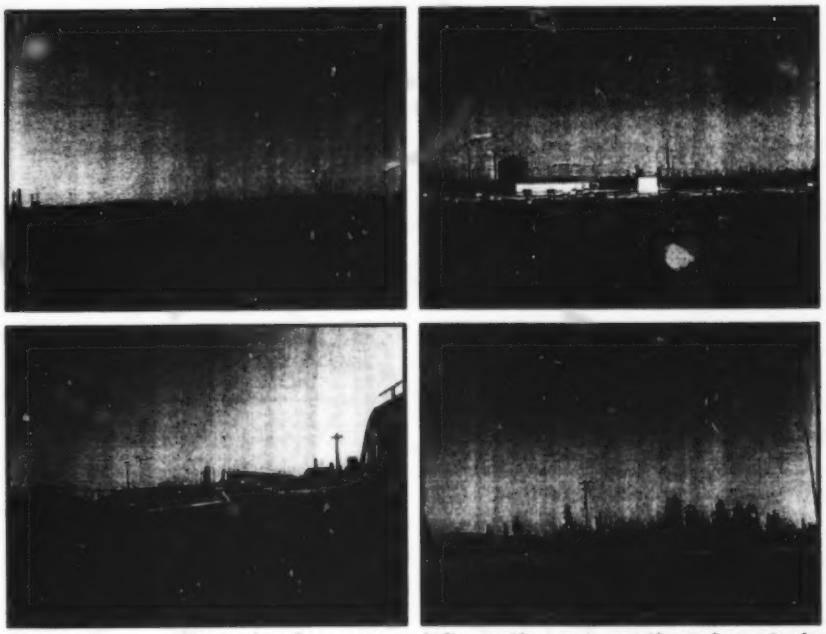

Figure 3: **Clockwise from upper left: north, east, south and west views of monitoring location #18 onsite at CNRL Primrose Operations (June 3, 2004).**

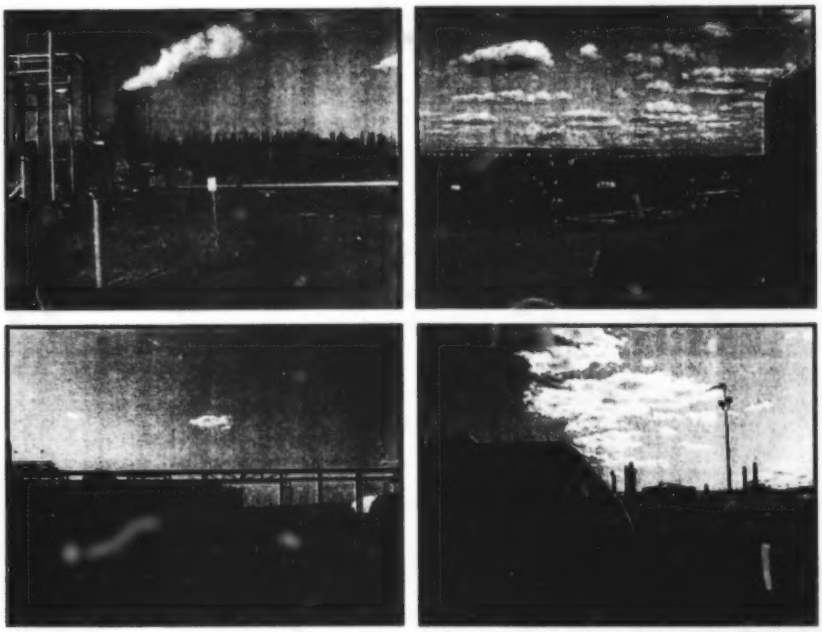

Figure 4: **Clockwise from upper left: north, east, south and west views of monitoring location #17 onsite at EnCana Foster Creek Operations (June 3, 2004)**

Results Discussion

Tables A1 and A2 in Appendix A contain median and maximum air pollutant levels at locations monitored off-site. Tables A3 and A4 show median and maximum air pollutant concentrations at other locations in Alberta, including other monitoring surveys. Hourly air pollutant concentrations for ambient site locations on each survey day are provided in Table A5. Weather conditions and the MAML operator's comments for ambient site monitoring sites are tabulated in Table A6.

In the following sections, the monitoring results are discussed and the median and maximum 1-hour concentrations are presented on accompanying graphs. The maximum concentration is the highest 1-hour concentration measured at the given location. The median concentration is a common way of representing the central value for environmental data. Most environmental data usually consist of a distribution that is skewed to the right; that is most data values are low and only a few are high. The arithmetic mean will be biased by the high concentrations and will reveal a value that may not be representative of the central value for the data set. The median is the middlemost value in the data set, dividing the distribution into two equal halves. Therefore, the median is more representative of the central value of the data distribution. Fifty percent of the values in the dataset are below the median and fifty percent are above.

For example, consider a data distribution consisting of five numbers: 1, 2, 2, 3 and 10. The arithmetic mean of these data is 3.6 and the median is 2. In this case, the arithmetic mean is biased high by the extreme value of 10. The median value is actually a true central value of the data distribution.

Many areas in Alberta are pristine and certain pollutants that Alberta Environment monitors for are found in concentrations below the lower detection limit of the instruments onboard the MAML. Consider a dataset that contains 4 concentrations below the detection limit and 1 concentration within the operating range of the MAML instruments; with this data set, it is possible to have an overall median concentration that is 'undetectable' or below the lower detection limit while still having a 'detectable' maximum value.

The following diagram explains how to interpret the graphs in the following sections:

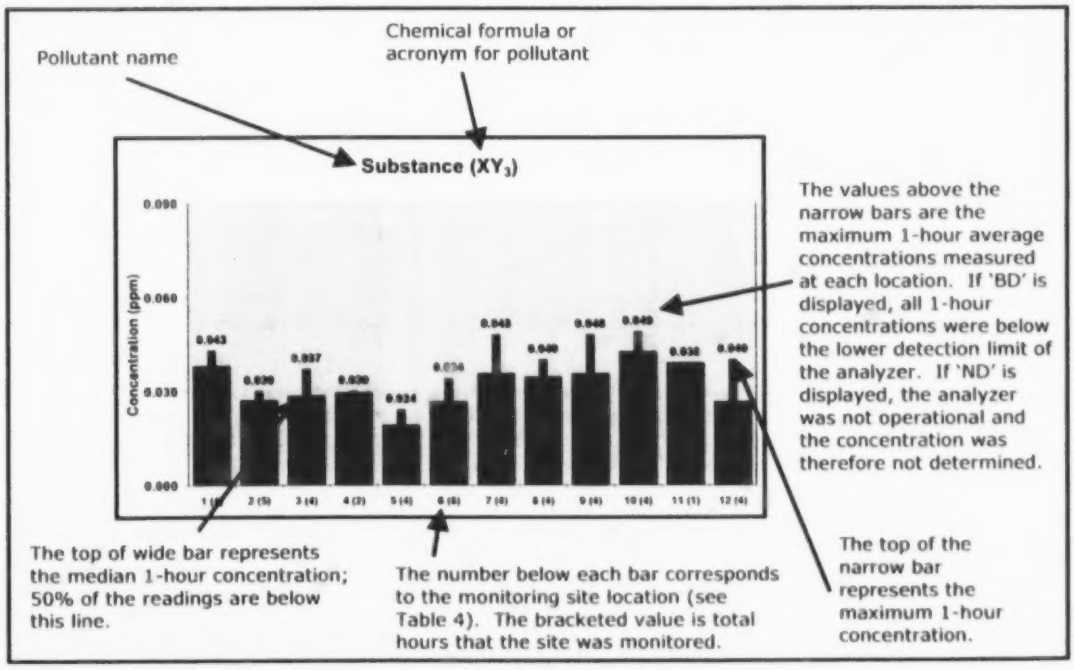
Pollutant name
Chemical formula or acronym for pollutant
Substance (XY_3)
Concentration (ppm)
0.090
0.060
0.030
0.000
The values above the narrow bars are the maximum 1-hour average concentrations measured at each location. If 'BD' is displayed, all 1-hour concentrations were below the lower detection limit of the analyzer. If 'ND' is displayed, the analyzer was not operational and the concentration was therefore not determined.
The top of wide bar represents the median 1-hour concentration; 50% of the readings are below this line.
The number below each bar corresponds to the monitoring site location (see Table 4). The bracketed value is total hours that the site was monitored.
The top of the narrow bar represents the maximum 1-hour concentration.

Figure 5: Key for interpreting the graphs in the following section.

Ammonia (NH_3)

Ammonia is a colourless gas with the well-known pungent odour; it is commonly found in household cleaners. NH_3 is produced both by natural and man-made sources. Some natural sources of NH_3 include the decay of plant material and animal waste. A small portion is also released during respiration. In Alberta, the fertilizer industry is the main industrial source of NH_3. The industry produces synthetic NH_3 for either direct application to soil as a fertilizer or as a raw material for use in the production of other high nitrogen fertilizer products. The other major source of NH_3 is commercial feedlots, specifically from their large amounts of decaying animal wastes.

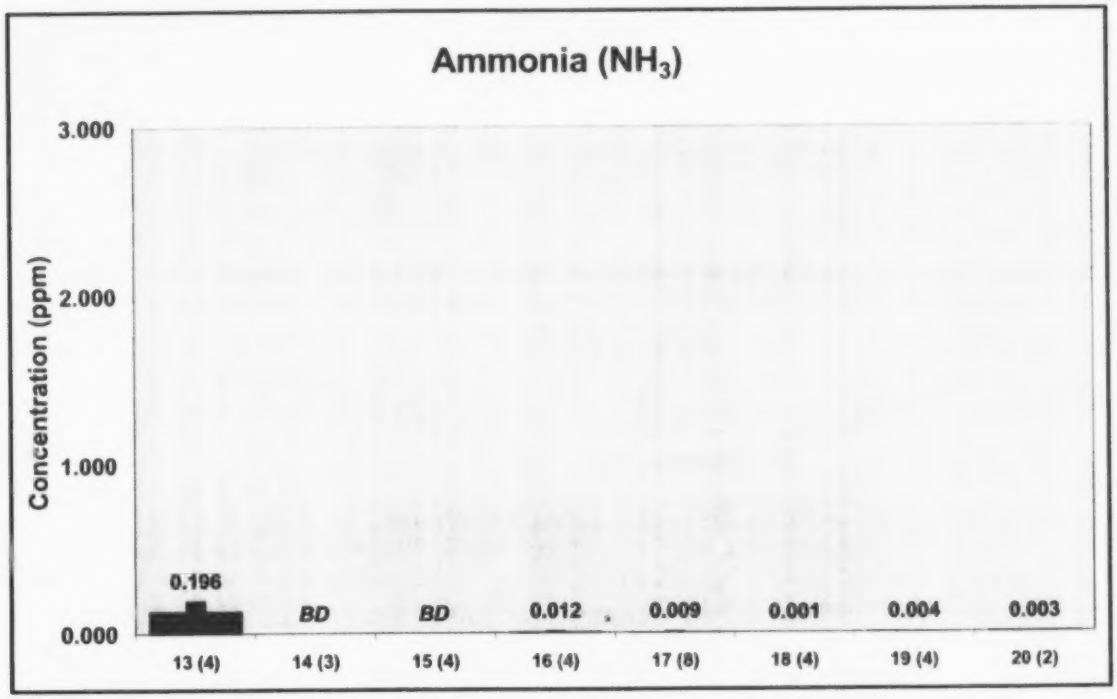

Figure 6: One-hour median and maximum concentrations for ammonia.

Carbon Monoxide (CO)

Carbon monoxide (CO) is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles. Minor sources include fireplaces, industry, aircraft and natural gas combustion. The major source of carbon monoxide in urban locations is vehicle exhaust emissions.

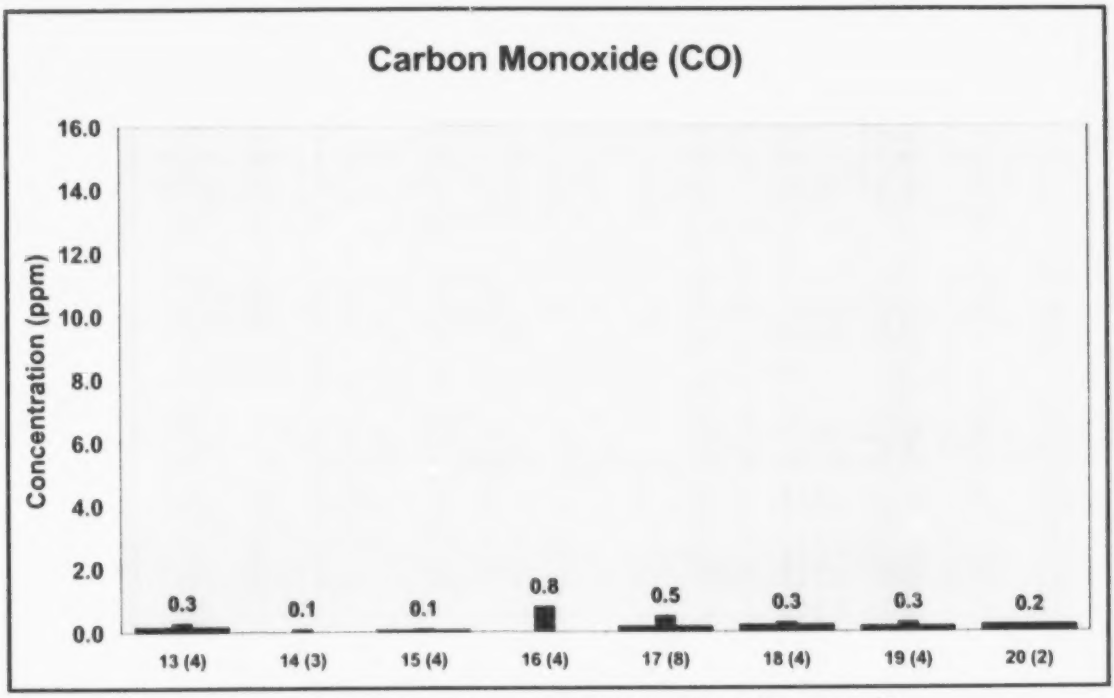

Figure 7: **One-hour median and maximum concentrations for carbon monoxide.**

Hydrocarbons (CH_4, RHC, THC, PAHs)

The term "total hydrocarbons" (THC) refers to a broad family of chemicals that contain carbon and hydrogen atoms. Methane (CH_4) is the most common natural hydrocarbon in the earth's atmosphere. Reactive hydrocarbons (RHC) are important because they can contribute to summertime smog or be toxic at high concentrations. Some sources of hydrocarbons include vegetation, vehicle emissions, oil and gas processing, chemical processing, dry cleaning, fireplaces, natural gas combustion, aircraft traffic and evaporation of solvents.

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that are usually contained in soot and smoke. There are more than 100 different PAHs with varying levels of toxicity. They are formed during the incomplete combustion of gasoline, diesel, oil, coal, wood, garbage or other organic substances. Tobacco smoke and charbroiled meats are common sources of PAHs. Other outdoor PAH sources include vehicle emissions, wood smoke from fireplaces, smoke from forest fires and industrial facilities. PAHs occur in the atmosphere in the vapour phase or attached to dust particles. The PAH monitoring instrument aboard the MAML will analyze only particulate bound PAHs.

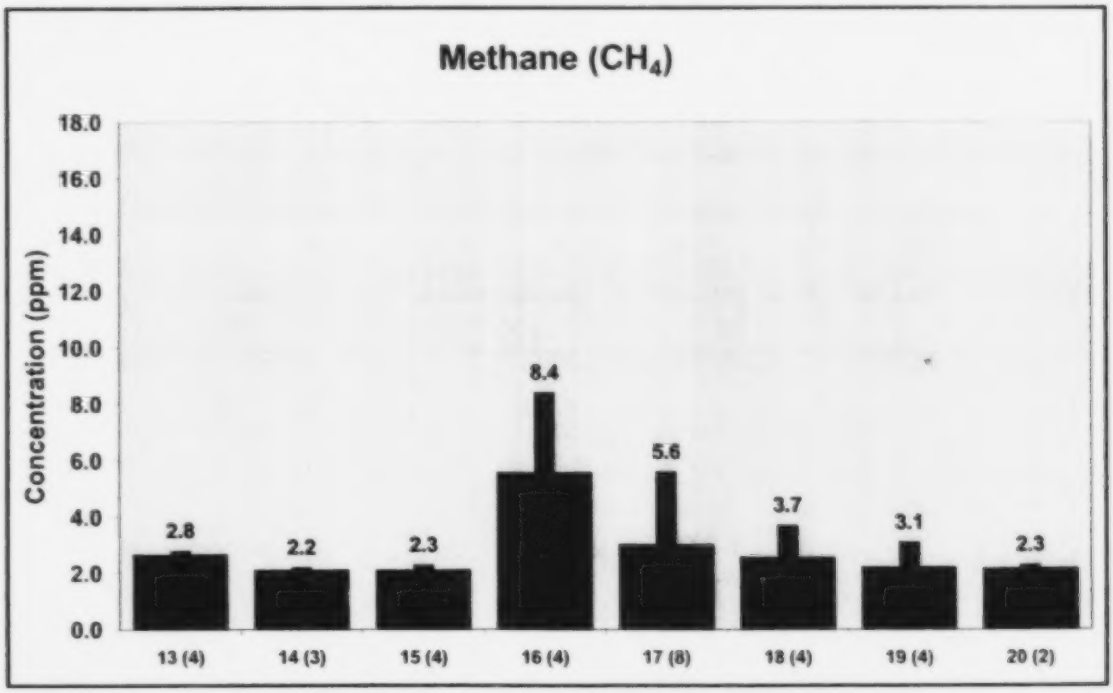

Figure 8: **One-hour median and maximum concentrations for methane.**

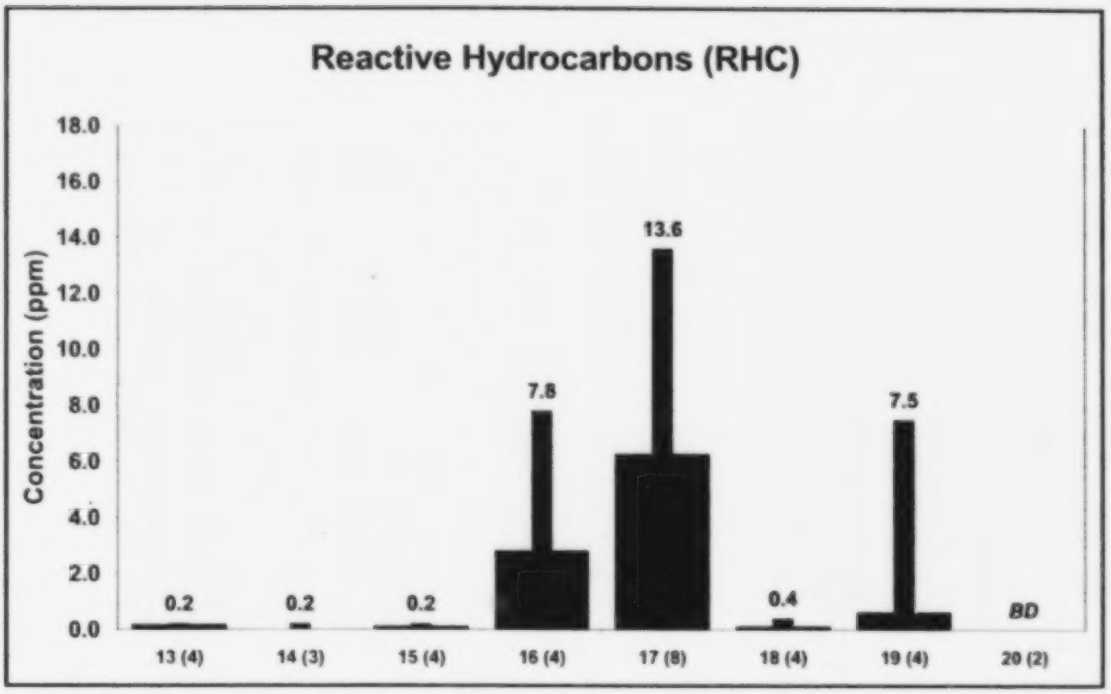

Figure 9: One-hour median and maximum concentrations for reactive hydrocarbons.

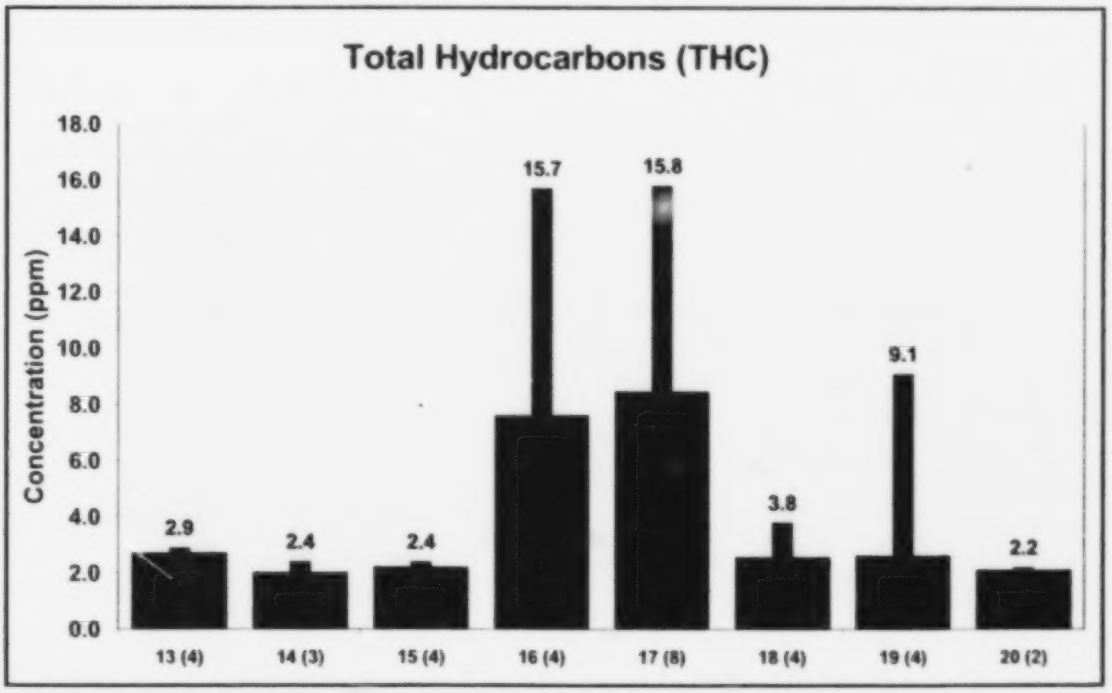

Figure 10: One-hour median and maximum concentrations for total hydrocarbons.

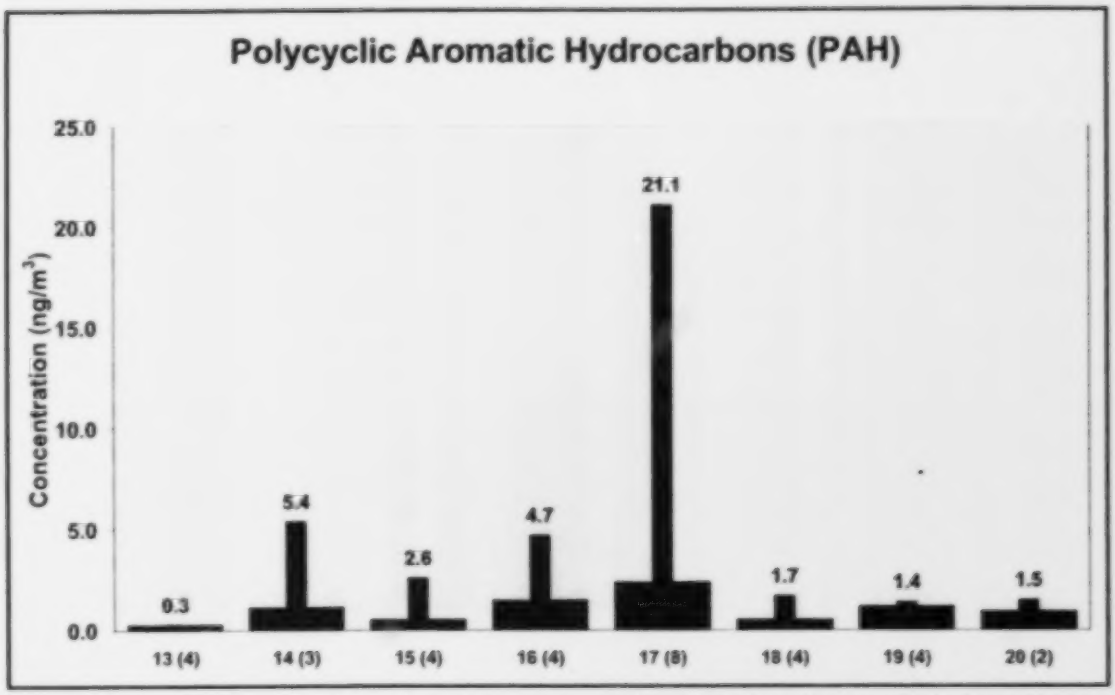

Figure 11: One-hour median and maximum concentrations for polycyclic aromatic hydrocarbons.

Oxides of Nitrogen (NO_2, NO, NO_x)

Oxides of nitrogen (NO_x) are the total of nitrogen dioxide (NO_2) and nitric oxide (NO). During high temperature combustion - as in the burning of natural gas, coal, oil and gasoline - atmospheric nitrogen may combine with molecular oxygen to form NO. NO is colourless and odourless. Most NO in the ambient air is oxidized to form NO_2. NO2 is a reddish-brown gas with a pungent odour. The major sources of oxides of nitrogen in urban areas are vehicle emissions and emissions from power plants. Processes associated with the oil and gas industry also emit oxides of nitrogen into the atmosphere.

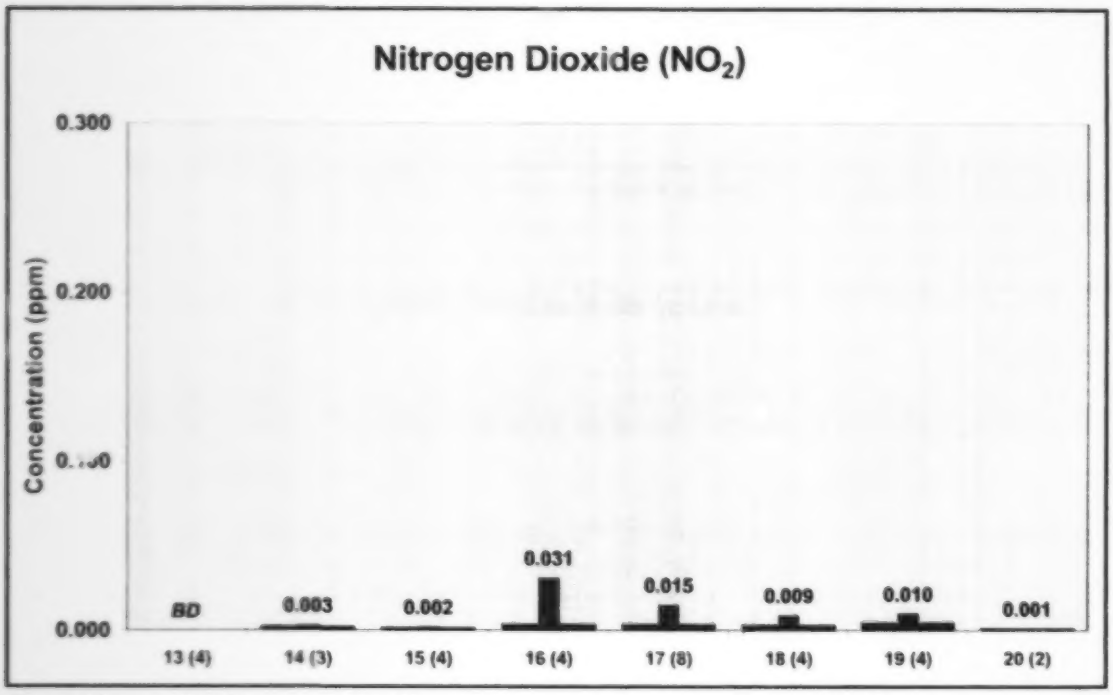

Figure 12: **One-hour median and maximum concentrations for nitrogen dioxide**

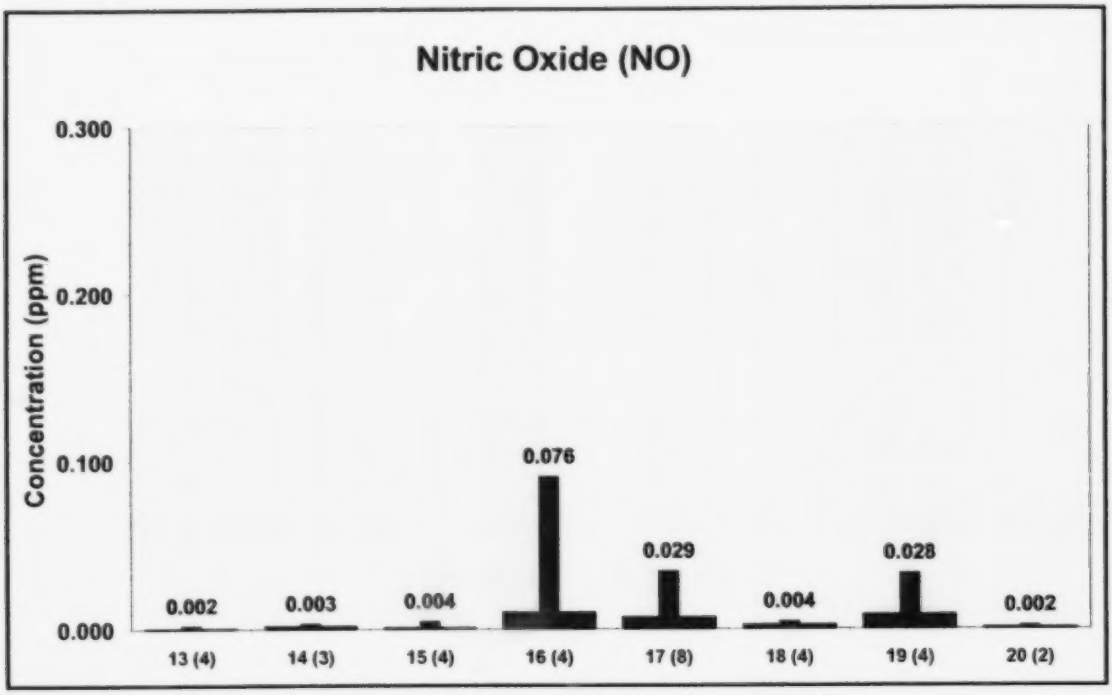

Figure 13: One-hour median and maximum concentrations for nitric oxide.

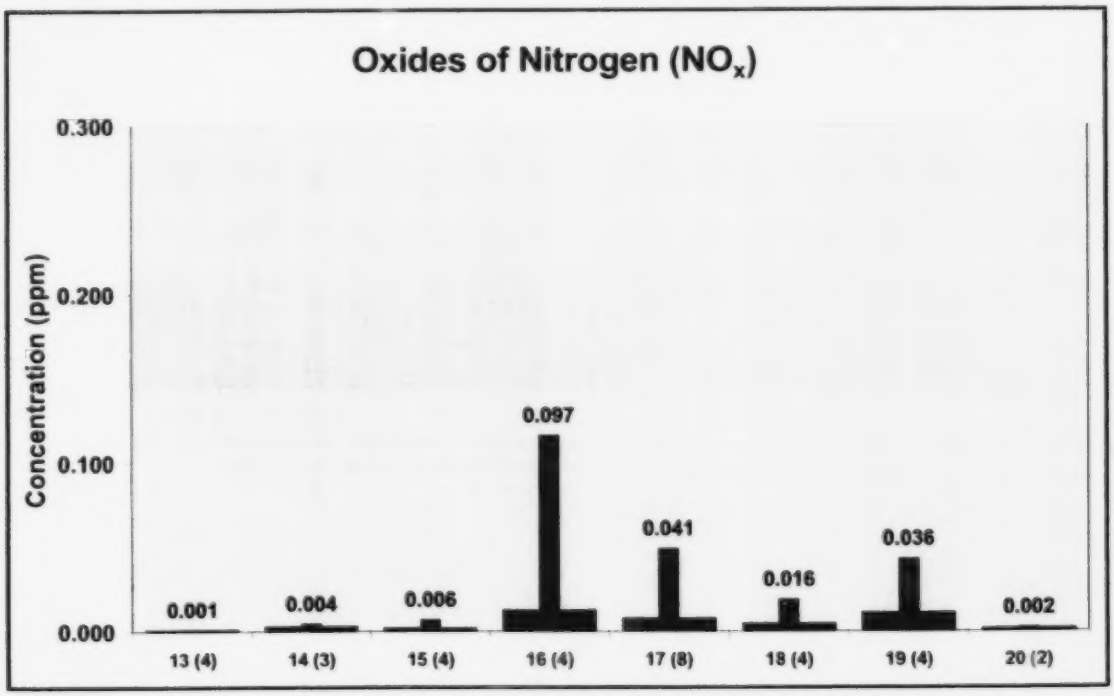

Figure 14: One-hour median and maximum concentrations for oxides of nitrogen.

Ozone (O_3)

Ozone in the lower atmosphere is produced by the reaction of oxides of nitrogen and volatile organic compounds in the presence of sunlight, and transport of O_3 from the upper atmosphere to ground level. Transport from the upper atmosphere is likely the dominant ozone producing process in the fall, winter and early spring seasons. O_3 concentrations are generally lower in urban centres due to the destruction of O_3 by nitric oxide..

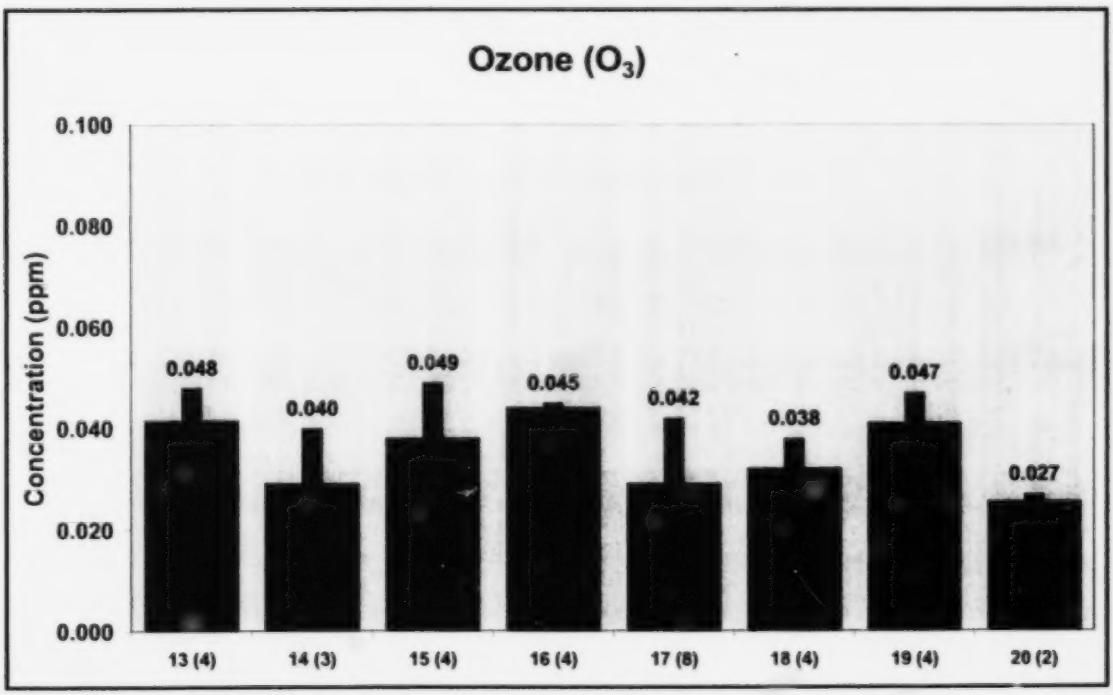

Figure 15: **One-hour median and maximum concentrations for ozone.**

Particulate Matter (TSP, PM_{10}, $PM_{2.5}$)

Total suspended particulates (TSP) refer to all particles up to 500 μm (micrometers) in diameter (a human hair is about 70μm in diameter) and are important primarily from a nuisance perspective. Particles less than 10 μm in diameter (PM_{10}) can be inhaled into the nose and throat while smaller particles, less than 2.5 μm in diameter ($PM_{2.5}$), can penetrate into the lungs. Sources of coarse particulate matter (PM10) include soil dust, resuspended road dust, agricultural dust (e.g., harvest), smoke from forest fires and wood burning. Fine particulate matter ($PM_{2.5}$) can originate in the atmosphere because of condensation processes and from combustion processes from sources such as vehicles emissions, industrial emissions, wood burning and forest fires.

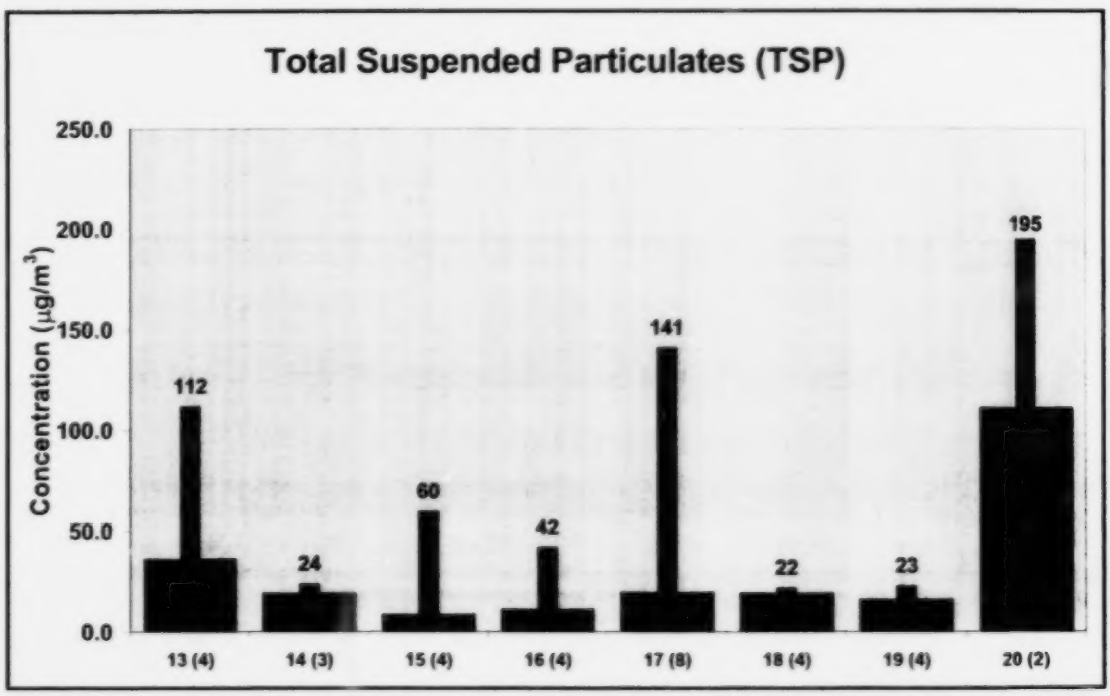

Figure 16: **One-hour median and maximum concentrations for total suspended particulates (TSP).**

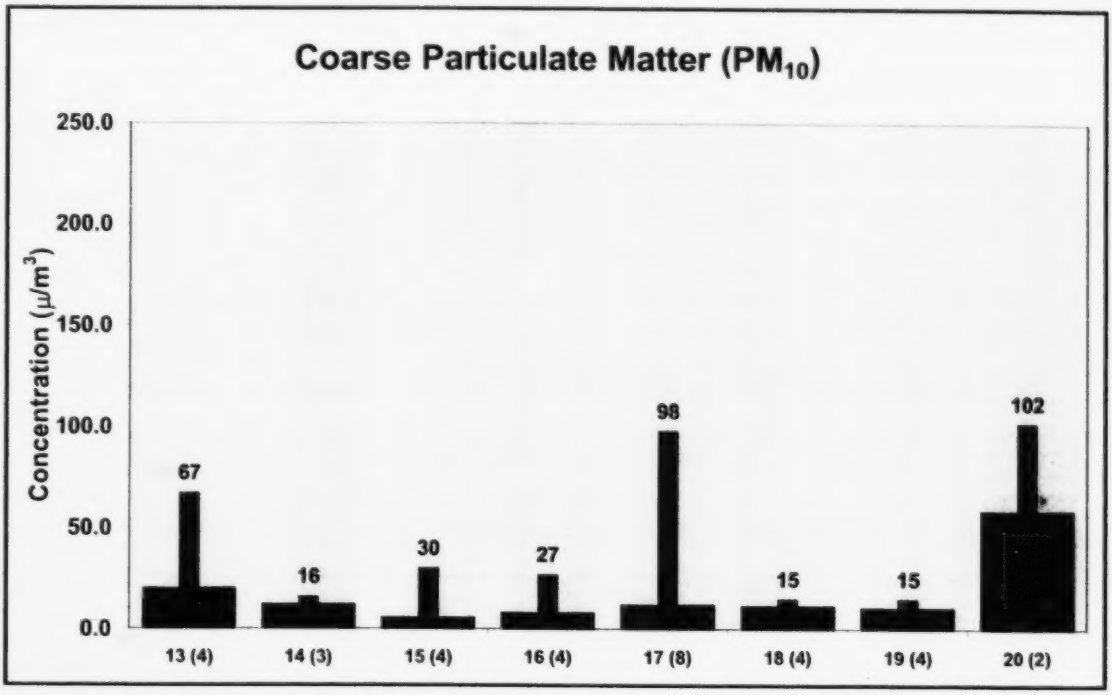

Figure 17: One-hour median and maximum concentrations for coarse particulate matter (PM_{10}).

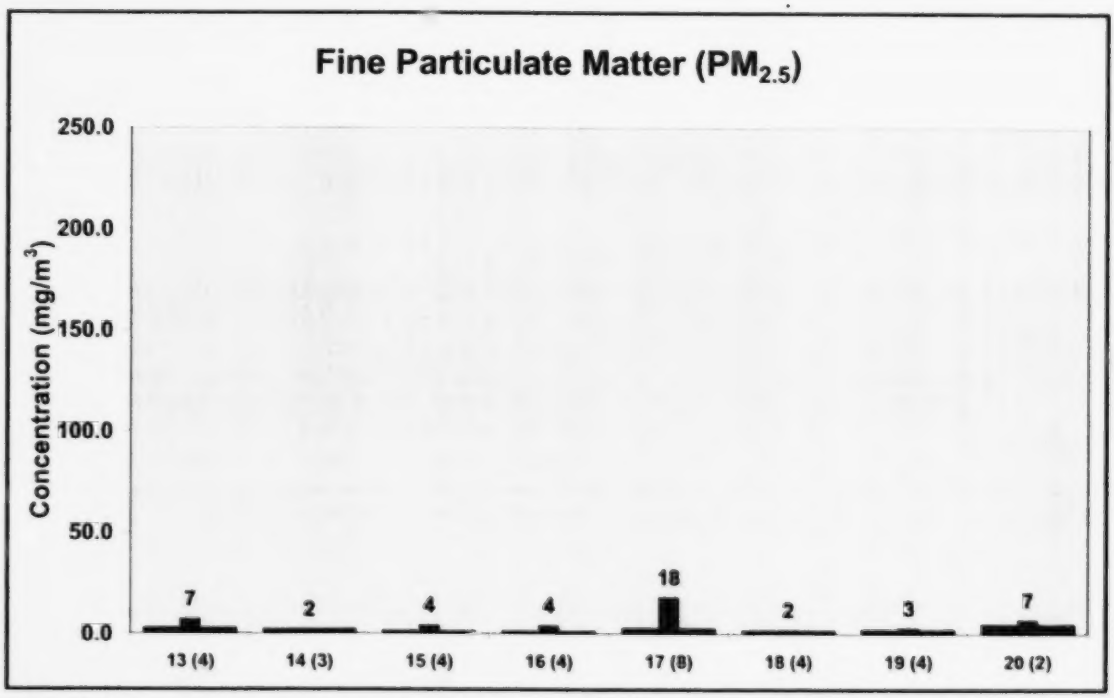

Figure 18: One-hour median and maximum concentrations for fine particlulate matter ($PM_{2.5}$).

Hydrogen Sulphide and Total Reduced Sulphur (H_2S and TRS)

Hydrogen sulphide (H_2S) is a colourless gas with a rotten egg odour. Total reduced sulphur (TRS) includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide is not included in the determination of TRS. Industrial sources of H_2S and TRS include fugitive emissions (leakages) from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities, pulp and paper plants that use the kraft pulping process, and animal feedlots. Natural sources of H_2S include sulphur hot springs, sloughs, swamps and lakes.

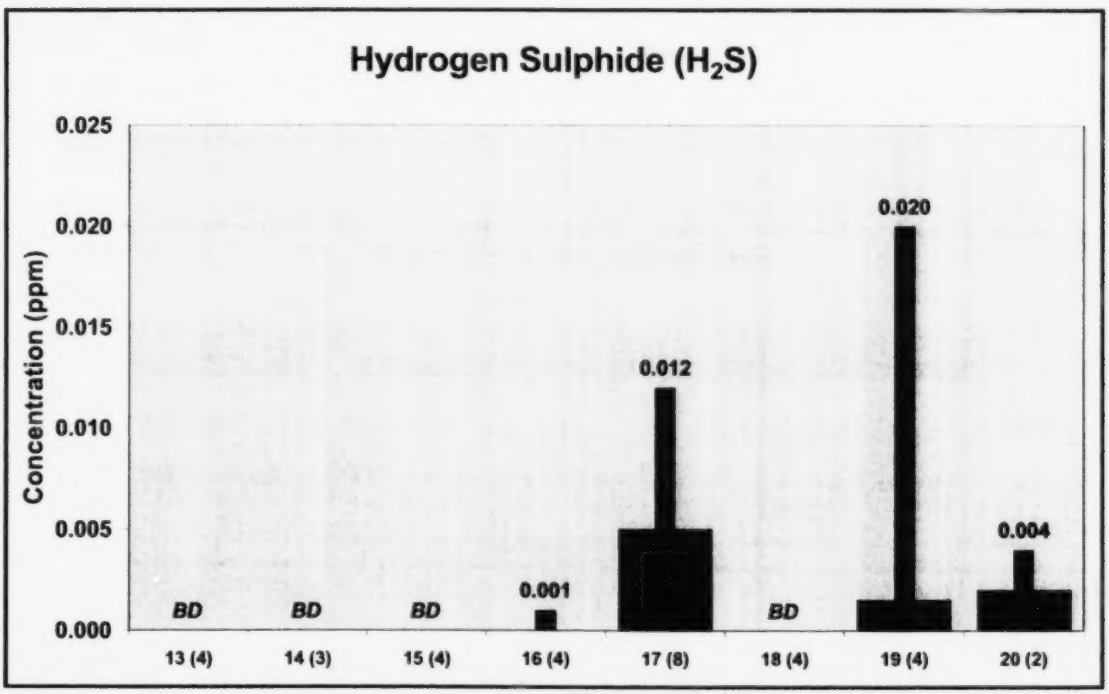

Figure 19: One-hour median and maximum concentrations for hydrogen sulphide

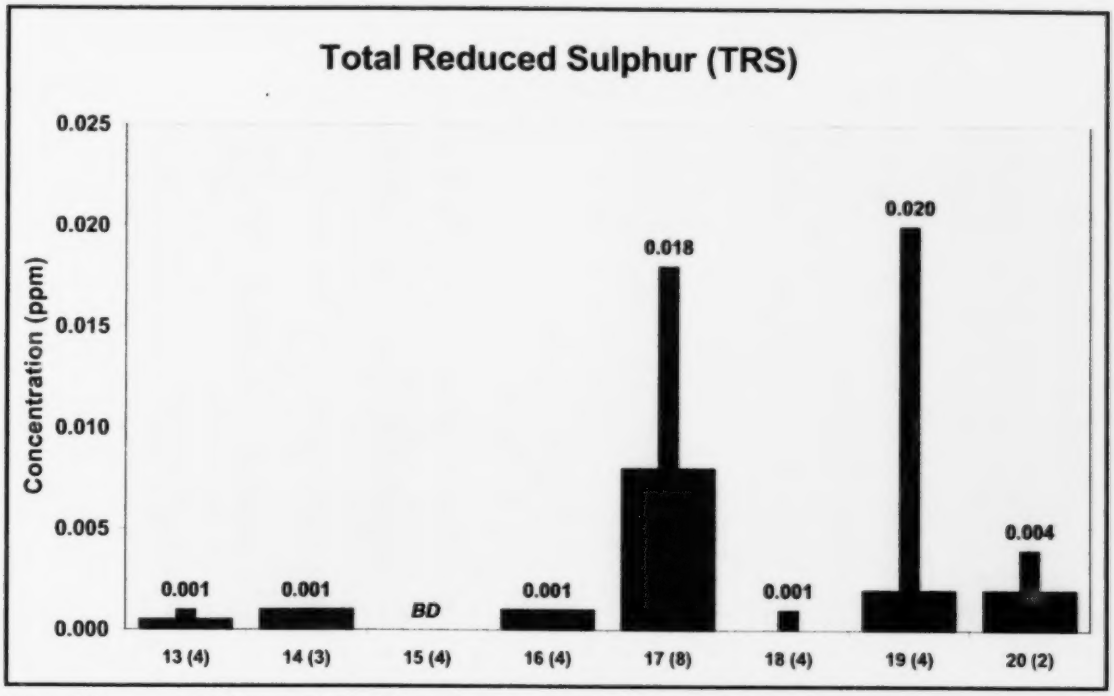

Figure 20: One-hour median and maximum concentrations for total reduced sulphur.

Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is a colourless gas with a pungent odour. In Alberta, it is estimated that 45% of SO_2 emissions are produced by natural gas processing plants while oil sands and power plants produce about 26% and 21% of SO_2 emissions, respectively. Other sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

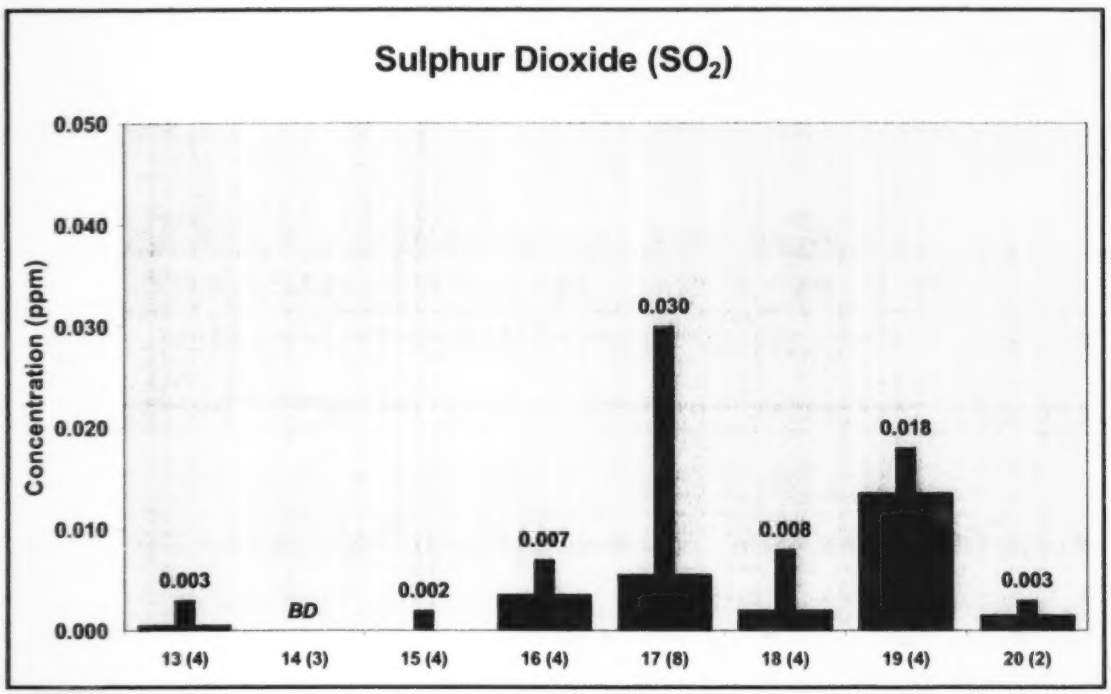

Figure 21: **One-hour median and maximum concentrations for sulphur dioxide.**

Appendix A

Monitoring Data

Table A1 Median one-hour air pollutant ambient site concentrations for the 2003-2004 Lakeland Area survey.

Monitoring Location		Hydrocarbons						Oxides of Nitrogen				Particulates			Sulphur Compounds		
		NH_3	CO	CH_4	RHC	THC	PAH	NO_2	NO	NO_x	O_3	TSP	PM_{10}	$PM_{2.5}$	H_2S	TRS	SO_2
		ppm	ppm	ppm	ppm	ppm	ng/m^3	ppm	ppm	ppm	ppm	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	ppm	ppm	ppm
13.	Private Feedlot	0.131	0.2	2.7	0.2	2.7	0.3	bd	0.001	0.001	0.042	36	20	3	bd	0.001	0.001
14.	Grande Centre Landfill	bd	bd	2.1	bd	2.0	1.1	0.002	0.002	0.003	0.029	19	12	2	bd	0.001	bd
15.	CFB Cold Lake	bd	0.1	2.1	0.1	2.2	0.5	0.002	0.001	0.002	0.038	9	6	1	bd	bd	bd
16.	Exxon Mobil Wolf Lake. LSD 15-12-63-6W4M	0.004	bd	5.6	2.8	7.6	1.5	0.004	0.010	0.013	0.044	11	8	1	bd	0.001	0.004
17.	Encana Foster Creek. LSD 22-70-4W4M	0.001	0.2	3.0	6.3	8.5	2.4	0.004	0.007	0.008	0.029	20	12	3	0.005	0.008	0.006
18.	CNRL Primrose. LSD N1/2-5-. 67-4W4M	bd	0.2	2.6	0.1	2.6	0.5	0.003	0.003	0.005	0.032	19	12	2	bd	bd	0.002
19.	Imperial Oil Mahkeses	0.001	0.2	2.2	0.6	2.6	1.2	0.005	0.009	0.011	0.041	16	11	2	0.002	0.002	0.014
20.	JACOS Hangingstone. LSD 13-26-84-11W4M	0.003	0.2	2.2	bd	2.1	0.9	0.001	0.001	0.002	0.026	111	59	5	0.002	0.002	0.002

ND - not determined (analyzer not functioning)
bd - below detection limit of analyzer

Table A2 **Maximum one-hour air pollutant ambient site concentrations for the 2003-2004 Lakeland Area survey.**

	Monitoring Location			Hydrocarbons				Oxides of Nitrogen				Particulates			Sulphur Compounds		
		NH_3	CO	CH_4	RHC	THC	PAH	NO_2	NO	NO_x	O_3	TSP	PM_{10}	$PM_{2.5}$	H_2S	TRS	SO_2
		ppm	ppm	ppm	ppm	ppm	ng/m^3	ppm	ppm	ppm	ppm	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	ppm	ppm	ppm
13.	Private Feedlot	0.196	0.3	2.8	0.2	2.9	0.3	bd	0.002	0.001	0.048	112	67	7	bd	0.001	0.003
14.	Grande Centre Landfill	bd	0.1	2.2	0.2	2.4	5.4	0.003	0.003	0.004	0.040	24	16	2	bd	0.001	bd
15.	CFB Cold Lake	bd	0.1	2.3	0.2	2.4	2.6	0.002	0.004	0.006	0.049	60	30	4	bd	bd	0.002
16.	Exxon Mobil Wolf Lake. LSD 15-12-63-6W4M	0.012	0.8	8.4	7.8	15.7	4.7	0.031	0.076	0.097	0.045	42	27	4	0.001	0.001	0.007
17.	Encana Foster Creek. LSD 22-70-4W4M	0.009	0.5	5.6	13.6	15.8	21.1	0.015	0.029	0.041	0.042	141	98	18	0.012	0.018	0.030
18.	CNRL Primrose. LSD N1/2-5-67-4W4M	0.001	0.3	3.7	0.4	3.8	1.7	0.009	0.004	0.016	0.038	22	15	2	bd	0.001	0.008
19.	Imperial Oil Mahkeses	0.004	0.3	3.1	7.5	9.1	1.4	0.010	0.028	0.036	0.047	23	15	3	0.020	0.020	0.018
20.	JACOS Hangingstone. LSD 13-26-84-11W4M	0.003	0.2	2.3	bd	2.2	1.5	0.001	0.002	0.002	0.027	195	102	7	0.004	0.004	0.003

ND – not determined (analyzer not functioning)
bd – below detection limit of analyzer

Table A3 Median one-hour air pollutant concentrations in Alberta.

Air Quality Station	Station or Survey Type	Monitoring Period	CO ppm	O_3 ppm	THC ppm	CH_4 ppm	RHC ppm	SO_2 ppm	NO_2 ppm	NH_3 ppm	TRS ppm	H_2S ppm	TSP $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PAHs ng/m^3
Onsite Industrial Lakeland Area[1] (current)	mobile survey	May 2003 to Sep. 2004	0.1	0.037	2.9	2.6	0.2	0.002	0.002	0.001	0.001	bd	19	11	2	1
Lakeland Area[1]	mobile survey	May 2003 to Sep. 2004	0.2	0.031	2.6	2.4	0.2	bd	0.002	0.002	bd	bd	14	9	1	1
Banff[1]	mobile survey	Nov. 19 to 22, 2003	0.5	0.018	2.7	2.5	0.2	0.000	0.008	0.004	0.000	0.001	7	5	1	11
Fort Saskatchewan/Redwater1	mobile survey	May 2001 to Mar. 2002	0.3	0.029	2.1	2.1	0.1	0.001	0.004	0.001	bd	bd	39	22	3	bd
Cold Lake/Bonnieville/Elk Point[1]	mobile survey	Mar. 2001 to Feb. 2002	0.2	0.031	2.1	1.9	0.1	0.000	0.003	0.000	0.001	0.000	16	10	2	1
Whitecourt/Swan Hills/Shiningbank Lake[1]	mobile survey	Mar. 2001 to June 2001	0.2	0.027	2.3	2.0	0.3	0.004	0.005	0.001	0.001	0.000	47	29	4	1
Wabuman[1]	mobile survey	July 2000 to Sep. 2001	0.2	0.027	2.0	1.9	0.1	0.002	0.005	0.004	0.000	0.000	34	22	3	1
Edmonton (Whitemud Drive)[1]	mobile survey	June 2000 to July 2001	0.4	0.019	2.2	2.0	0.1	0.002	0.014	0.00	0.000	0.000	41	24	3	8
Bow Corridor[1]	mobile survey	Dec. 1999 to Sep. 2000	0.2	0.030	1.9	1.8	0.1	0.001	0.007	0.001	0.001	0.000	74	40	4	4
Permanent Continuous Monitoring Stations																
Beaverlodge[2]	rural	Jan. 2003 to Dec. 2003	n/a	0.027	n/a	n/a	n/a	0.000	0.004	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Calgary Central[2]	urban	Jan. 2003 to Dec. 2003	0.4	0.015	2.1	n/a	n/a	n/a	0.025	n/a	n/a	n/a	n/a	18	5	n/a
Calgary East[2]	urban	Jan. 2003 to Dec. 2003	0.5	0.015	2.1	n/a	n/a	0.002	0.024	n/a	n/a	0.001	n/a	n/a	7	n/a
Calgary Northwest[2]	urban	Jan. 2003 to Dec. 2003	0.3	0.024	2.0	n/a	n/a	n/a	0.015	n/a	n/a	n/a	n/a	n/a	4	n/a
Edmonton Central[2]	urban	Jan. 2003 to Dec. 2003	0.5	0.016	2.2	n/a	n/a	n/a	0.023	n/a	n/a	n/a	n/a	n/a	5	n/a
Edmonton East[2]	urban	Jan. 2003 to Dec. 2003	0.3	0.022	2.2	n/a	n/a	0.00	0.014	n/a	n/a	0.000	n/a	n/a	5	n/a
Edmonton Northwest[2]	urban	Jan. 2003 to Dec. 2003	0.4	0.021	2.0	n/a	n/a	n/a	0.020	n/a	n/a	n/a	n/a	17	6	n/a
Fort Saskatchewan[2]	small urban	Jan. 2003 to Dec. 2003	3.8	0.023	1.9	n/a	n/a	0.001	0.008	0.001	n/a	bd	n/a	n/a	4	n/a
Red Deer[2]	small urban	Jan. 2003 to Dec. 2003	0.3	0.021	2.1	n/a	n/a	0.000	0.011	n/a	n/a	0.000	n/a	n/a	4	n/a
Buffalo Viewpoint[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	1.9	n/a	n/a	0.000	n/a	n/a	n/a	0.000	n/a	n/a	n/a	n/a
Fort Chipewyan[3]	rural	Jan. 2003 to Dec. 2003	n/a	0.065	n/a	n/a	n/a	0.018	0.030	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fort McKay[3]	rural	Jan. 2003 to Dec. 2003	n/a	0.022	1.8	n/a	n/a	0.000	0.035	n/a	0.001	n/a	n/a	n/a	3	n/a
Fort McMurray (Athabasca Valley)[3]	small urban	Jan. 2003 to Dec. 2003	0.2	0.018	3.5	n/a	n/a	0.000	0.080	n/a	0.001	n/a	n/a	n/a	3	n/a
Fort McMurray (Patricia McInnes)[3]	small urban	Jan. 2003 to Dec. 2003	n/a	0.023	1.9	n/a	n/a	0.000	0.003	n/a	0.000	n/a	n/a	n/a	2	n/a
Mannix[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	1.9	n/a	n/a	0.001	n/a	n/a	n/a	0.000	n/a	n/a	n/a	n/a
Mildred Lake[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	2.1	n/a	n/a	0.001	n/a	n/a	n/a	0.000	n/a	n/a	n/a	n/a
Carrot Creek[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.029	n/a	n/a	n/a	0.001	0.006	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hightower Ridge[4]	background	Jan. 2003 to Dec. 2003	n/a	0.044	n/a	n/a	n/a	0.000	0.000	n/a	n/a	n/a	n/a	5	2	n/a
Steeper[4]	rural	Jan. 2003 to Dec. 2003	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tomahawk[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.031	n/a	n/a	n/a	0.001	0.003	n/a	n/a	n/a	n/a	9	3	n/a
Violet Grove[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.034	2.0	n/a	n/a	0.001	0.002	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sherwood Park[5]	small urban	Jan. 2003 to Dec. 2003	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Caroline[6]	rural	Jan. 2003 to Dec. 2003	n/a	0.034	2.2	0.0	n/a	0.000	0.003	n/a	0.000	0.000	n/a	n/a	n/a	n/a

1 - Mobile survey conducted by Alberta Environment.
2 - Station operated by Alberta Environment.
3 - Station operated by the Wood Buffalo Environmental Association.
4 - Station operated by the West Central Airshed Society.
5 - Station operated by the Strathcona Industrial Association.
6 - Station operated by the Parkland Airshed Management Association.
n/a - Parameter not monitored or data not available.

ND - not determined (analyzer not functioning)
bd - below detection limit of analyzer

Table A4 **Maximum one-hour air pollutant concentrations in Alberta.**

Air Quality Station	Station or Survey Type	Monitoring Period	CO ppm	O_3 ppm	THC ppm	CH_4 ppm	RHC ppm	SO_2 ppm	NO_2 ppm	NH_3 ppm	TRS ppm	H_2S ppm	TSP $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PAHs ng/m^3
Onsite Industrial Lakeland Area[1] (current)	mobile survey	May 2003 to Sep. 2004	0.8	0.049	15.8	8.4	13.6	0.030	0.031	0.196	0.020	0.020	195	102	18	21
Lakeland Area[1]	mobile survey	May 2003 to Sep. 2004	0.9	0.049	7.2	4.1	4.6	0.009	0.012	0.013	0.003	0.003	1505	1074	127	14
Banff[1]	mobile survey	Nov. 19 to 22, 2003	1.5	0.034	3.6	3.1	0.8	0.002	0.033	0.013	0.001	0.003	37	23	21	105
Fort Saskatchewan/Redwater[1]	mobile survey	May 2001 to Mar. 2002	2.2	0.049	3.6	3.6	0.5	0.022	0.051	0.577	0.004	0.003	547	323	24	70
Cold Lake/Bonnieville/Elk Point[1]	mobile survey	Mar. 2001 to Feb. 2002	1.4	0.047	9.7	4.6	7.1	0.017	0.014	0.005	0.056	0.054	2281	1188	72	14
Whitecourt/Swan Hills/Shiningbank Lake[1]	mobile survey	Mar. 2001 to June 2001	0.7	0.054	4.3	2.5	2.5	0.046	0.030	0.013	0.005	0.003	946	441	43	113
Wabuman[1]	mobile survey	July 2000 to Sep. 2001	0.5	0.057	3.3	3.2	0.5	0.032	0.015	0.020	0.003	0.001	807	534	42	11
Edmonton (Whitemud Drive)[1]	mobile survey	June 2000 to July 2001	2.7	0.059	4.4	2.7	1.6	0.015	0.041	0.039	0.005	0.003	459	239	37	77
Bow Corridor[1]	mobile survey	Dec. 1999 to Sep. 2000	1.1	0.056	7.8	2.2	6.6	0.092	0.031	0.034	0.004	0.002	2082	1094	60	36
Permanent Continuous Monitoring Stations																
Beaverlodge[2]	rural	Jan. 2003 to Dec. 2003	n/a	0.060	n/a	n/a	n/a	0.080	0.038	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Calgary Central[2]	urban	Jan. 2003 to Dec. 2003	5.2	0.072	4.0	n/a	n/a	n/a	0.087	n/a	n/a	n/a	n/a	243	204	n/a
Calgary East[2]	urban	Jan. 2003 to Dec. 2003	5.4	0.072	5.3	n/a	n/a	0.022	0.114	n/a	n/a	0.018	n/a	n/a	224	n/a
Calgary Northwest[2]	urban	Jan. 2003 to Dec. 2003	3.4	0.094	3.3	n/a	n/a	n/a	0.065	n/a	n/a	n/a	n/a	n/a	208	n/a
Edmonton Central[2]	urban	Jan. 2003 to Dec. 2003	6.5	0.076	5.2	n/a	n/a	n/a	0.089	n/a	n/a	n/a	n/a	n/a	82	n/a
Edmonton East[2]	urban	Jan. 2003 to Dec. 2003	2.3	0.084	14.7	n/a	n/a	0.07	0.082	n/a	n/a	0.016	n/a	n/a	250	n/a
Edmonton Northwest[2]	urban	Jan. 2003 to Dec. 2003	5.9	0.091	6.1	n/a	n/a	n/a	0.109	n/a	n/a	n/a	n/a	328	97	n/a
Fort Saskatchewan[2]	small urban	Jan. 2003 to Dec. 2003	3.1	0.085	7.8	n/a	n/a	0.056	0.082	0.121	n/a	0.008	n/a	n/a	132	n/a
Red Deer[2]	small urban	Jan. 2003 to Dec. 2003	3.6	0.086	7.4	n/a	n/a	0.018	0.068	n/a	n/a	0.005	n/a	n/a	73	n/a
Buffalo Viewpoint[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	6.3	n/a	n/a	0.102	n/a	n/a	n/a	0.023	n/a	n/a	n/a	n/a
Fort Chipewyan[3]	rural	Jan. 2003 to Dec. 2003	n/a	0.063	n/a	n/a	n/a	0.020	0.043	n/a	n/a	n/a	n/a	n/a	49	n/a
Fort McKay[3]	rural	Jan. 2003 to Dec. 2003	n/a	0.084	11.1	n/a	n/a	0.095	0.035	n/a	0.008	n/a	n/a	n/a	81	n/a
Fort McMurray (Athabasca Valley)[3]	small urban	Jan. 2003 to Dec. 2003	2.9	0.063	3.7	n/a	n/a	0.044	0.063	n/a	0.007	n/a	n/a	n/a	48	n/a
Fort McMurray (Patricia McInnes)[3]	small urban	Jan. 2003 to Dec. 2003	n/a	0.059	3.0	n/a	n/a	0.048	0.040	n/a	0.005	n/a	n/a	n/a	63	n/a
Mannix[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	7.0	n/a	n/a	0.180	n/a	n/a	n/a	0.028	n/a	n/a	n/a	n/a
Mildred Lake[3]	industrial	Jan. 2003 to Dec. 2003	n/a	n/a	9.6	n/a	n/a	0.147	n/a	n/a	n/a	0.014	n/a	n/a	n/a	n/a
Carrot Creek[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.076	n/a	n/a	n/a	0.000	0.155	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hightower Ridge[4]	background	Jan. 2003 to Dec. 2003	n/a	0.067	n/a	n/a	n/a	0.009	0.014	n/a	n/a	n/a	n/a	84	77	n/a
Steeper[4]	rural	Jan. 2003 to Dec. 2003	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tomahawk[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.083	n/a	n/a	n/a	0.038	0.032	n/a	n/a	n/a	n/a	149	56	n/a
Violet Grove[4]	rural	Jan. 2003 to Dec. 2003	n/a	0.077	15.0	n/a	n/a	0.050	0.026	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sherwood Park[5]	small urban	Jan. 2003 to Dec. 2003	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Caroline[6]	rural	Jan. 2003 to Dec. 2003	n/a	0.084	8.1	0.0	n/a	0.074	0.035	n/a	0.051	0.046	n/a	n/a	n/a	n/a

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n/a - Parameter not monitored or data not available.

ND - not determined (analyzer not functioning)
bd - below detection limit of analyzer

Table A5 Chronological listing of all one-hour average concentrations measured during the 2003-2004 Lakeland Area survey.

Site #	Date	Times (MST)	CO ppm	NH_3 ppm	CH_4 ppm	RHC ppm	THC ppm	PAH ng/m³	NO_2 ppm	NO ppm	NO_x ppm	O_3 ppm	TSP µg/m³	PM_{10} mg/m³	$PM_{2.5}$ mg/m³	H_2S ppm	SO_2 ppm	TRS ppm
13	26-May-03	13:51 to 14:51	0.2	0.100	2.8	0.2	2.9	0.2	0.000	0.001	0.000	0.042	18	9	1	0.000	0.001	0.000
13	26-May-03	15:03 to 16:03	0.2	0.300	2.8	0.1	2.8	0.2	0.000	0.002	0.001	0.041	33	16	2	0.000	0.000	0.000
15	27-May-03	12:53 to 13:53	0.0	0.000	2.1	0.2	2.4	0.5	0.002	0.000	0.001	0.049	6	4	1	0.000	0.000	0.000
19	27-May-03	14:43 to 15:43	0.0	0.100	1.8	0.5	2.2	1.2	0.002	0.001	0.002	0.047	11	7	2	0.000	0.000	0.001
17	28-May-03	09:19 to 10:19	0.0	0.200	2.9	2.9	5.4	2.9	0.002	0.003	0.004	0.042	17	10	2	0.004	0.008	0.003
17	28-May-03	10:19 to 11:19	0.0	0.200	4.4	9.6	12.7	3.4	0.004	0.007	0.009	0.039	22	14	3	0.012	0.018	0.009
16	28-May-03	14:00 to 15:00	0.0	0.000	4.4	1.5	5.2	2.1	0.003	0.005	0.007	0.045	42	27	4	0.000	0.000	0.001
16	29-May-03	08:19 to 09:19	0.0	0.800	3.1	0.7	3.5	4.7	0.031	0.076	0.097	0.037	6	4	1	0.001	0.001	0.002
19	29-May-03	12:06 to 13:06	0.0	0.200	2.0	0.2	2.2	0.8	0.007	0.010	0.014	0.037	7	4	1	0.001	0.002	0.017
15	29-May-03	13:56 to 14:56	0.0	0.100	2.3	0.1	2.4	2.6	0.001	0.001	0.002	0.043	7	4	1	0.000	0.000	0.000
14	29-May-03	15:27 to 16:27	0.0	0.100	2.2	0.2	2.4	1.1	0.002	0.002	0.003	0.040	10	6	1	0.000	0.001	0.000
13	8-Sep-03	15:52 to 16:52	0.0	0.200	2.4	0.0	2.3	0.3	0.000	0.000	0.001	0.028	112	67	7	0.000	0.001	0.001
19	9-Sep-03	12:26 to 13:26	0.0	0.000	2.4	0.7	3.0	1.4	0.010	0.028	0.036	ND	23	15	3	0.002	0.002	0.018
14	9-Sep-03	14:13 to 15:13	0.0	0.000	1.9	0.0	1.9	0.7	0.002	0.002	0.003	0.025	19	12	2	0.000	0.001	0.000
15	9-Sep-03	15:31 to 16:31	0.0	0.100	1.9	0.1	2.0	0.2	0.001	0.001	0.002	0.026	60	30	4	0.000	0.000	0.000
17	10-Sep-03	09:52 to 10:52	0.0	0.000	2.8	10.1	11.5	0.8	0.004	0.009	0.010	0.018	4	3	1	0.008	0.008	0.004
17	10-Sep-03	11:13 to 12:13	0.0	0.000	3.2	13.6	14.6	0.4	0.002	0.007	0.006	0.020	7	4	1	0.012	0.014	0.007
14	10-Sep-03	15:39 to 16:39	0.0	0.000	2.1	0.0	2.0	5.4	0.003	0.003	0.004	0.029	24	16	2	0.000	0.000	0.000
15	11-Sep-03	08:35 to 09:35	0.0	0.000	2.1	0.0	2.0	0.5	0.002	0.004	0.006	0.033	10	7	1	0.000	0.000	0.002
19	11-Sep-03	10:28 to 11:28	0.0	0.300	3.1	7.5	9.1	1.1	0.002	0.007	0.008	0.041	21	14	2	0.020	0.020	0.010
16	11-Sep-03	12:01 to 13:01	0.0	0.000	6.7	4.1	10.0	0.8	0.002	0.006	0.007	0.045	10	7	1	0.000	0.001	0.005
16	11-Sep-03	13:06 to 14:06	0.0	0.000	8.4	7.8	15.7	0.7	0.004	0.014	0.018	0.043	12	9	1	0.000	0.001	0.007
13	11-Sep-03	16:15 to 17:15	0.1	0.000	2.6	0.2	2.6	0.3	0.000	0.000	0.001	0.048	39	24	3	0.000	0.000	0.003
17	3-Jun-04	15:02 to 16:02	0.0	0.500	3.1	0.2	3.2	0.5	0.003	0.001	0.006	0.036	54	30	3	0.000	0.001	0.030
17	3-Jun-04	16:08 to 17:08	0.0	0.100	5.6	12.9	15.8	1.8	0.001	0.000	0.003	0.039	93	55	5	0.006	0.008	0.007
18	3-Jun-04	18:04 to 19:04	0.0	0.100	3.7	0.4	3.8	0.5	0.009	0.004	0.016	0.035	17	10	1	0.000	0.000	0.008
18	3-Jun-04	19:04 to 20:04	0.0	0.000	2.9	0.1	2.9	0.2	0.004	0.001	0.005	0.038	13	8	1	0.000	0.000	0.002
20	15-Sep-04	09:41 to 10:41	0.0	0.200	2.3	0.0	2.2	1.5	0.001	0.002	0.002	0.024	27	15	2	0.004	0.004	0.003
20	15-Sep-04	10:55 to 11:55	0.0	0.200	2.0	0.0	2.0	0.3	0.001	0.000	0.001	0.027	195	102	7	0.000	0.000	0.000
17	16-Sep-04	10:28 to 11:28	0.0	0.100	2.6	0.3	2.9	3.3	0.008	0.016	0.025	0.021	12	8	1	0.003	0.003	0.001
17	16-Sep-04	11:36 to 12:22	0.0	0.300	2.2	0.2	2.3	21.1	0.015	0.029	0.041	0.022	141	98	18	0.002	0.003	0.001
18	16-Sep-04	13:25 to 14:25	0.0	0.300	2.1	0.1	2.1	0.5	0.002	0.002	0.004	0.029	21	13	2	0.000	0.000	0.001
18	16-Sep-04	14:25 to 15:25	0.0	0.300	2.2	0.1	2.2	1.7	0.001	0.003	0.003	0.029	22	15	2	0.000	0.001	0.002

ND = not determined (analyzer not functioning)
bd = below detection limit of analyzer

Table A6 **Weather Conditions and Operator's Remarks in the 2003-2004 Lakeland Area survey, (Spring and Fall 2003/2004) for ambient site monitoring locations.**

Date	Site	Time	Temp.	Relative Humidity	Wind Speed	Wind Direction	Operator's Remarks
		(MST)	°C	%	km/h	degrees	
26-May-03	13	13:51 to 14:51	21.1	43.0	12.6	83	Typical feedlot odours (NH3) and particulates
26-May-03	13	15:03 to 16:03	19.0	49.6	17.0	54	Typical feedlot odours (NH3) and particulates
27-May-03	15	12:53 to 13:53	25.5	16.9	20.3	297	Odours from taxing jets about 200m from MAML
27-May-03	19	14:43 to 15:43	24.6	19.5	8.1	245	Trace SO2 detected
28-May-03	17	09:19 to 10:19	21.9	27.5	13.0	249	Set out canister ser #2162 at 10:20 am MST for 20 sec grab sample
28-May-03	17	10:19 to 11:19	22.1	27.9	14.8	230	
28-May-03	16	14:00 to 15:00	25.4	26.3	9.9	189	Elevated hydrocarbons and particulate from truck traffic
29-May-03	16	08:19 to 09:19	15.6	79.0	14.5	297	20m downwind of tank. Visit from Exxon representative.
29-May-03	19	12:06 to 13:06	17.7	54.3	13.3	266	Slightly elevated SO2 and NOX
29-May-03	15	13:56 to 14:56	17.8	47.4	30.7	308	No elevated readings
29-May-03	14	15:27 to 16:27	17.4	51.4	10.9	289	No elevated readings
8-Sep-03	13	15:52 to 16:52	16.9	55.9	16.2	315	Downwind of light odours about 130m SE of cattle. After 6 min., move to 68m from cattle. Estimated 1000 head. 100% Overcast.
9-Sep-03	19	12:26 to 13:26	10.2	109.0	21.3	262	Stop at SE corner and downwind on plant site 128m from nearest structure. Odours detected. 100% overcast and rain.
9-Sep-03	14	14:13 to 15:13	9.9	117.7	18.3	243	Elevated particulate from road dust. Can't get directly downwind of major activity. 100% overcast and rain.
9-Sep-03	15	15:31 to 16:31	10.4	114.1	21.3	301	No odours. No jet activity. 100% overcast and rain.
10-Sep-03	17	09:52 to 10:52	11.3	88.5	15.5	300	Stop on SE corner (boundary) of plant site 120m SW of stack and south of nearest tanks about same distance. Elevated Hydrocarbons. 100% overcast with very light rain.
10-Sep-03	17	11:13 to 12:13	14.0	78.1	14.0	301	Same location as previous hour. Hourly averages match the same time the canister samples were taken.
10-Sep-03	14	15:39 to 16:39	20.1	42.0	15.2	275	No elevated readings however cannot get downwind of main activity. 50% overcast.
11-Sep-03	15	08:35 to 09:35	13.7	73.5	21.5	322	Monitor at the viewing area on base. Jet activity. No odours. 90% overcast (no rain).
11-Sep-03	19	10:28 to 11:28	16.1	52.1	13.8	265	Sample on SE side of plant on site. Pick up odours. After 10 min. re-locate 30m further north and downwind of all activity.
11-Sep-03	16	12:01 to 13:01	20.0	34.4	11.8	272	Sample on site about 50m east of tanks. No truck activity so RHC emmissions are fugitive. 60% overcast.
11-Sep-03	16	13:06 to 14:06	19.0	36.1	17.7	277	Sample on site about 40-50m east of tanks. 2-3 trucks unloading. Elevated RHC. 80% overcast.
11-Sep-03	13	16:15 to 17:15	18.0	32.3	12.5	274	Stop in center of feedlot. About 1000 head. Elevated NH3 and particulate. 1000's of flies, flies, flies. 40% overcast.
3-Jun-04	17	15:02 to 16:02	22.3	25.2	14.1	256	Pad C. Furthest location MAML can access.
3-Jun-04	17	16:08 to 17:08	23.3	22.9	15.0	294	109m SE of flare stack. Same spot as previous survey
3-Jun-04	18	18:04 to 19:04	22.4	24.8	13.1	264	320m east of SO2 flare stack. Not on site.

Table A6 (...continued) Weather Conditions and Operator's Remarks in the 2003-2004 Lakeland Area survey, (Spring and Fall 2003/2004) for ambient site monitoring locations.

Date	Site	Time	Temp.	Relative Humidity	Wind Speed	Wind Direction	Operator's Remarks
		(MST)	°C	%	km/h	degrees	
3-Jun-04	18	19:04 to 20:04	21.1	28.1	7.5	296	320m east of SO2 flare stack.
15-Sep-04	20	09:41 to 10:41	15.6	57.9	7.4	158	Onsight at NE corner of plant. As close to downwind as possible
15-Sep-04	20	10:55 to 11:55	17.6	47.5	7.5	251	Onsight at NE corner of plant. As close to downwind as possible
16-Sep-04	17	10:28 to 11:28	15.4	50.8	7.9	202	On site at SE side of plant 125m SE of flare stack. Heavy equipment operating in
16-Sep-04	17	11:36 to 12:22	16.0	44.9	7.7	231	the area.
16-Sep-04	18	13:25 to 14:25	16.4	38.3	5.3	260	200m and 70m south of flare stack and 2 steam outlets respectively.
16-Sep-04	18	14:25 to 15:25	15.2	50.0	6.2	103	200m and 70m south of flare stack and 2 steam outlets respectively.

Table A7 Volatile Organic Compound (VOC) Canister Sampling - Concentrations at EnCana Foster Creek.

EnCana Foster Creek Onsite VOC Concentration - Grab Sample Comparison (µg/m³)								
Survey	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Near three Residences in the Fort Sask. Area	**Alberta One-hour Objective[a]**	**Ontario Half-hour Point of Impingement Limit[b]**	**Odour Threshold Range[c,d]**	
Site	EnCana Foster Creek	EnCana Foster Creek	EnCana Foster Creek	Residential Areas				
Dates	May 28, 2003	September 10, 2003	September 10, 2003	August 23 - November 29, 2001				
Sample Type	One 20-Second Grab Sample	One 1-hour integrated sample	One 1-hour integrated sample	Five 20-Second Grab Samples				
Compound Name	Actual Concentration	Actual Concentration	Actual Concentration	Median of five Samples			**Low**	**High**
1,1,1-Trichloroethane	bd	0.16	0.16	0.88		350000	122135	
1,1,2,2-Tetrachloroethane	bd	bd	bd	bd			21000	35000
1,1,2-Trichloroethane	bd	bd	bd	bd				
1,1-Dichloroethane	bd	bd	bd	0.34		600	891536	
1,1-Dichloroethene	bd	bd	bd	bd		30		
1,2,3-Trimethylbenzene	0.56	0.20	0.46	0.70				
1,2,4-Trichlorobenzene	1.52	0.24	0.16	0.01		100	24000	
1,2,4-Trimethylbenzene	1.04	0.60	1.98	0.66		500		
1,2-Dibromoethane (EDB)	bd	bd	bd	bd		9	75800	
1,2-Dichlorobenzene	0.48	0.06	0.04	bd		37000	12000	300000
1,2-Dichloroethane	1.84	1.02	0.56	5.84		6	24000	44000
1,2-Dichloropropane	bd	0.02	0.00	bd		2400	1167	606666
1,2-Diethylbenzene	0.48	0.02	0.04	0.36				
1,3,5-Trimethylbenzene	0.48	0.30	1.10	0.24				
1,3-Butadiene	bd	0.02	0.00	0.72			352	2860
1,3-Dichlorobenzene	0.40	0.06	0.04	bd				
1,3-Diethylbenzene	0.48	0.04	0.08	0.28				
1,4-Dichlorobenzene	0.64	0.18	0.14	0.32		285	288	
1,4-Dichlorobutane	bd	0.00	0.00	bd				
1,4-Diethylbenzene	0.64	0.08	0.24	0.74				
1-Butene/2-Methylpropene	1.36	0.30	0.24	0.60				
1-Butyne	bd	bd	bd	bd				
1-Decene	bd	bd	0.40	bd		180000		
1-Heptene	17.92	bd	bd	bd				
1-Hexene/2-Methyl-1-Pentene	bd	0.14	bd	0.62				
1-Methylcyclohexene	bd	0.18	0.12	bd				
1-Methylcyclopentene	0.32	0.30	0.16	bd				
1-Nonene	bd	0.00	1.96	0.56				
1-Octene	bd	bd	bd	2.64		150000		
1-Pentene	0.80	0.10	0.10	0.72				
1-Undecene	bd	bd	bd	bd				
2,2,3-Trimethylbutane	2.56	2.14	1.14	bd				
2,2,4-Trimethylpentane	bd	bd	bd	6.18				
2,2,5-Trimethylhexane	bd	0.12	0.12	0.32				
2,2-Dimethylbutane	107.04	47.28	22.80	0.44				
2,2-Dimethylhexane	bd	bd	bd	bd				
2,2-Dimethylpentane	10.64	6.60	3.40	bd				
2,2-Dimethylpropane	115.60	46.02	24.66	bd				
2,3,4-Trimethylpentane	0.16	0.56	0.38	1.46				
2,3-Dimethylbutane	161.44	74.22	36.14	0.20				
2,3-Dimethylpentane	15.92	13.32	7.78	3.07				
2,4-Dimethylhexane	2.08	2.32	1.90	1.24				
2,4-Dimethylpentane	17.84	12.88	6.66	1.80				
2,5-Dimethylhexane	1.92	2.16	1.78	0.88				
2-Ethyl-1-Butene	bd	0.00	0.00	bd				
2-Ethyltoluene	0.32	0.16	0.42	0.20				
2-Methyl-1-Butene	1.12	bd	bd	0.02				
2-Methyl-2-Butene	2.08	0.08	0.06	0.32				
2-Methylbutane	14576.48	3036.32	1738.70	1.96				
2-Methylheptane	8.40	11.74	12.12	0.82				
2-Methylhexane	62.00	53.22	30.86	1.02				
2-Methylpentane	1159.60	480.32	237.52	1.00				
3,6-Dimethyloctane	bd	bd	bd	bd				

(continued...)

a - *Alberta Ambient Air Quality Objectives*. Alberta Environment. December 2004.

b - *Summary of Point of Impingement Standards, Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQCs)*. Standards Development Branch, Ontario Ministry of the Environment. September 2001.

c - *Odor Thresholds and Irritation Levels of Several Chemical substances: A review*. Jon Ruth. Am. Ind. Hyg. Assoc. J (47). 1986.

d - *3M 2001 Respirator Selection Guide*. 3M. www.3m.com. 2001.

bd - *below detection limit* ND - *Not Determined*

Table A7 (... continued) Volatile Organic Compound (VOC) Canister Sampling - Concentrations at EnCana Foster Creek.

EnCana Foster Creek Onsite VOC Concentration - Grab Sample Comparison (µg/m³)								
Survey	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Near three Residences in the Fort Sask. Area	**Alberta One-hour Objective[a]**	**Ontario Half-hour Point of Impingement Limit[b]**	**Odour Threshold Range[c,d]**	
Site	EnCana Foster Creek	EnCana Foster Creek	EnCana Foster Creek	Residential Areas				
Dates	May 28, 2003	September 10, 2003	September 10, 2003	August 23 - November 29, 2001				
Sample Type	One 20-Second Grab Sample	One 1-hour integrated sample	One 1-hour integrated sample	Five 20-Second Grab Samples				
Compound Name	Actual Concentration	Actual Concentration	Actual Concentration	Median of five Samples			**Low**	**High**
3-Ethyltoluene	0.56	0.38	1.12	0.26				
3-Methyl-1-Butene	0.40	0.08	0.04	bd				
3-Methyl-1-Pentene	bd	bd	bd	bd				
3-Methylheptane	4.08	5.18	5.98	0.48				
3-Methylhexane	52.80	44.82	26.54	1.24				
3-Methylpentane	505.28	234.60	115.86	0.64				
4-Ethyltoluene	0.40	0.20	0.54	0.20				
4-Methyl-1-Pentene	bd	bd	bd	bd				
4-Methylheptane	2.00	3.08	2.96	0.56				
Acetaldehyde	15.68	0.85	1.09	5.58	90		0.2	4140
Acetone	1172.56	bd	bd	2.04		48000	474667	1613860
Acetylene	ND	107.56	58.70	0.84		56000	657200	
a-Pinene	bd	bd	bd	0.20				
Benzene	175.36	bd	bd	0.48	30		4500	270000
Benzyl Chloride	0.08	bd	bd	bd			235	1550
b-Pinene	bd	0.04	0.04	bd				
Bromodichloromethane	bd	0.06	0.08	bd				
Bromoform	bd	0.04	0.04	0.02		165	5300000	
Bromomethane	bd	0.06	0.08	0.08		4000		
Bromotrichloromethane	bd	bd	bd	bd				
Butane	4940.96	886.44	494.92	2.44			2850	484610
c-1,2-Dichloroethene	bd	bd	bd	bd		315		
c-1,2-Dimethylcyclohexane	0.64	0.30	0.36	bd				
c-1,3-Dichloropropene	bd	bd	bd	bd				
c-1,3-Dimethylcyclohexane	4.24	5.62	6.94	0.80				
c-1,4/t-1,3-Dimethylcyclohexane	0.64	0.74	1.00	0.12				
c-2-Butene	0.64	0.16	0.10	0.24				
c-2-Heptene	bd	bd	bd	0.88				
c-2-Hexene	bd	0.06	0.04	bd				
c-2-Pentene	0.64	0.12	bd	bd				
c-3-Heptene	bd	bd	bd	0.34				
c-3-Methyl-2-Pentene	bd	0.08	0.08	bd				
c-4-Methyl-2-Pentene	bd	1.04	1.04	0.70				
Camphene	bd	128.32	69.38	0.01				
Carbontetrachloride	0.64	bd	bd	0.66		7.2	60000	128400
Chlorobenzene	bd	bd	bd	bd		4200	980	280000
Chloroethane	0.16	bd	bd	bd				
Chloroform	bd	0.08	0.08	5.84		300	250000	1000000
Chloromethane	1.60	0.12	0.06	bd		20000		
Cyclohexane	190.08	1.04	1.04	0.36		300000	1435	
Cyclohexene	bd	126.32	69.38	0.24				
Cyclopentane	427.68	143.90	70.94	0.72				
Cyclopentene	0.32	bd	bd	bd				
Decane	1.28	0.12	0.08	0.28				
Dibromochloromethane	bd	0.68	3.64	0.32				
Dibromomethane	0.80	bd	bd	bd				
Dichloromethane	1.04	0.20	0.20	0.74		5300	540000	2160000
Dodecane	1.92	0.30	0.30	0.60				
Ethane	ND	ND	ND	ND			184500	1105770
Ethanol	4.48	bd	bd	bd		19000	342	9890000
Ethylbenzene	4.48	1.50	2.32	bd		3000	8700	870000
Ethylbromide	bd	bd	bd	0.62			890000	
Ethylene	ND	ND	ND	ND			299000	4600000
Ethylene Oxide	bd	5.34	2.95	bd		15	520000	1400000

(continued...)

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bd - *below detection limit* ND - *Not Determined*

Table A7 (... continued) Volatile Organic Compound (VOC) Canister Sampling - Concentrations at EnCana Foster Creek.

EnCana Foster Creek Onsite VOC Concentration - Grab Sample Comparison (µg/m³)								
Survey	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Onsite Industrial in the Lakeland Area	Near three Residences in the Fort Sask. Area	**Alberta One-hour Objective[a]**	**Ontario Half-hour Point of Impingement Limit[b]**	**Odour Threshold Range[c, d]**	
Site	EnCana Foster Creek	EnCana Foster Creek	EnCana Foster Creek	Residential Areas				
Dates	May 29, 2003	September 10, 2003	September 10, 2003	August 23 - November 29, 2001				
Sample Type	One 20-Second Grab Sample	One 1-hour integrated sample	One 1-hour integrated sample	Five 20-Second Grab Samples				
Compound Name	Actual Concentration	Actual Concentration	Actual Concentration	Median of five Samples			**Low**	**High**
Freon 11	1.68	1.62	1.62	0.56		18000	28000	1170400
Freon 113	2.64	0.62	0.62	2.64		2400000	342000	3729626
Freon 114	1.76	0.14	0.14	0.72		2100000		
Freon 12	41.76	3.36	3.44	bd		1500000		
Freon 22	0.56	0.50	0.48	bd		1050000		
Heptane	81.12	80.62	53.58	6.18		33000	40013	1280000
Hexachlorobutadiene	3.52	0.02	bd	0.32			12000	
Hexane	994.40	476.54	240.28	0.44		35000	77141	
Hexylbenzene	1.04	bd	bd	bd				
Indan	0.32	0.08	0.10	bd				
Isobutane	703.92	127.38	72.68	bd				
iso-Butylbenzene	0.48	bd	0.10	1.46				
Isoprene	1.36	0.66	0.88	0.20				
iso-Propylbenzene	0.24	0.14	0.26	0.24		100		
Limonene	0.16	0.26	0.18	1.00				
m,p-Xylene	12.88	8.18	15.44	0.44		2300	348	174000
Methyl Alcohol	11.80	0.66	2.86	42.70		12000		
Methylcyclohexane	70.96	73.40	56.06	0.84			2000000	
Methylcyclopentane	338.48	163.24	83.52	0.68				
Methyl-t-Butyl Ether (MTBE)	bd	bd	bd	bd		2200		
Naphthalene	0.96	0.18	0.16	0.54		38	1500	125000
n-Butylbenzene	0.56	bd	0.08	0.36				
Nonane	1.76	2.58	8.76	0.36			6605	3412500
n-Propylbenzene	0.40	0.24	0.44	0.42				
Octane	7.76	12.14	17.68	0.72		45400	26846	1208330
o-Xylene	5.84	1.74	3.40	0.20			3693	
p-Cymene	2.08	bd	0.10	0.68				
Pentane	8116.16	2305.70	1298.58	0.78			6600	3000000
Propane	325.60	56.30	34.28	4.52			1800000	36000000
Propene	1.36	0.24	0.18	0.17				
Propyne	bd	bd	bd	0.48				
sec-Butylbenzene	0.32	bd	bd	bd				
Styrene	0.16	0.02	0.02	0.46	215	400	202	860000
t-1,2-Dichloroethene	bd	bd	bd	0.56				
t-1,2-Dimethylcyclohexane	2.40	4.32	5.12	0.28				
t-1,3-Dichloropropene	bd	bd	bd	bd				
t-1,4-Dimethylcyclohexane	1.92	2.60	3.22	0.32				
t-2-Butene	bd	bd	bd	0.48				
t-2-Heptene	bd	0.10	0.06	bd				
t-2-Hexene	0.32	0.14	0.08	bd				
t-2-Octene	bd	bd	bd	bd				
t-2-Pentene	1.60	0.38	0.20	bd				
t-3-Heptene	bd	bd	bd	bd				
t-3-Methyl-2-Pentene	bd	bd	bd	bd				
t-4-Methyl-2-Pentene	bd	bd	bd	bd				
tert-Butylbenzene	bd	bd	bd	bd				
Tetrachloroethene	bd	0.02	bd	0.24		10000		
Toluene	51.12	58.76	46.02	1.00		2000	8025	150000
Trichloroethene	bd	0.04	bd	0.16		3500		
Undecane	1.60	0.34	2.06	0.46				
Vinylchloride	bd	bd	bd	0.92	130	3	646	

a - *Alberta Ambient Air Quality Objectives*. Alberta Environment. December 2004.

b - *Summary of Point of Impingement Standards, Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQCs)*. Standards Development Branch, Ontario Ministry of the Environment. September 2001.

c - *Odor Thresholds and Irritation Levels of Several Chemical substances: A review*. Jon Ruth. Am. Ind. Hyg. Assoc. J (47). 1986.

d - *3M 2001 Respirator Selection Guide*. 3M. www.3m.com. 2001.

bd - *below detection limit* ND - *Not Determined*